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ABSTRACT

This document presents witness testimony and supplemental materials from a Congressional hearing called to evaluate the progress of the High Performance Computing and Communications program in light of budget requests, to examine the appropriate role for the government in such a project, and to see demonstrations of the World Wide Web and related technologies. It features opening statements by Senator Conrad Burns and by Senator Ernest Hollings, as well as prepared statements by Senator Larry Pressler, by Senator John D. Rockefeller IV, and by Senator Ted Stevens. Witnesses include: (1) John Toole, National Coordinating Office for High Performance Computing and Communications; (2) Bill Burrall, Moundsville Junior High, Moundsville (West Virginia); (3) Dr. Richard Gowen, South Dakota School of Mines and Technology; and (4) Steven Running, School of Forestry, University of Montana (Missoula). An appendix features transcriptions of John Toole's dialogues with Senators Pressler and Burns. (BEW)

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S. HRG. 104-191

OVERSIGHT HEARING ON THE HIGH PERFORMANCE COMPUTING AND COMMUNICATIONS PROGRAM AND USES OF THE INFORMATION HIGHWAY

ED 390 447

HEARING

BEFORE THE

SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE

OF THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION UNITED STATES SENATE

ONE HUNDRED FOURTH CONGRESS

FIRST SESSION

MAY 4, 1995

Printed for the use of the Committee on Commerce, Science, and Transportation

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HEARING ON THE HIGH PERFORMANCE COMPUTING AND COMMUNICATIONS PROGRAM AND USES OF THE INFORMATION HIGHWAY

THURSDAY, MAY 4, 1995

U.S. SENATE,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
Washington, DC.

The subcommittee met, pursuant to notice, at 10 a.m. in room SR–253, Russell Senate Office Building, Hon. Conrad Burns (chairman) presiding.

Staff members assigned to this hearing: Louis C. Whitsett, staff counsel, and Timothy B. Kyger, professional staff member; and Patrick H. Windham, minority senior professional staff.

OPENING STATEMENT SENATOR BURNS

Senator BURNS. Good morning. It is 10 a.m. I am going to try, as we may, to move through these hearings. I am an old auctioneer, and we advertise sale time at 10 a.m., at 10 a.m. we want to be cranking, because if we do not, why, we are a little short on the other end. We have got other things to do today, so we will start this.

The hearing today, the subcommittee will examine the HPCC Program, the high performance computing and communications program. This is the fourth year of support for the HPCC Program. As we review the fiscal year 1996 budget request for the program, this seems to be an appropriate point to evaluate its progress and to revisit the question of the appropriate role for Government in this kind of a project.

We also would like to see the demonstrations of the World Wide Web that we have heard so much about. The high performance computing and communications program that we will be examining here today was established by Congress in 1991 to perform the fundamental research and engineering to enable American industry to build what everyone has come to call the information highway, the super highway.

The program is intended to be as innovative as the technologies that this program is helping to develop. The HPCC Program is composed of activities funded in eight different Federal agencies, NASA being one, and of course NOAA, and five others.

These activities are coordinated by the national coordination office for the HPCC Program, which is part of the President's Office

of Science and Technology headed by Dr. John Toole, who is here with us today.

The HPCC Program has spent about $4 billion to date, and the administration is asking Congress for another $1.14 billion for fiscal year 1996.

The 1991 act authorized the program through 1996, so the subcommittee must now begin looking at whether the program should be reauthorized and, if so, at what level. Among these issues that we are closely examining in the hearing today: what have we gotten for our money so far, we are going to ask those questions, what activities are supported by this 1996 budget request, and what does the administration plan to do with the HPCC Program after 1996? In other words, do they plan to continue it?

In the second part of the hearing, we will be less concerned with oversight and more focused simply on looking at how these new computer technologies work. Politicians like myself have talked about for years the benefits of the information revolution that it will bring. Today, we will see their uses, demonstrated by people who actually rely on them. The information revolution may be only in its first phase, but there are people in the real world outside this beltway that are using a myriad of its applications. Today, we are going to see some of those applications.

It is one thing to talk about the information revolution, to make speeches on it, or to read about it in magazines or see stories about it on television, but it is quite another thing to see how we are actually using the Internet, or the World Wide Web.

Today we have with us four witnesses, each of whom uses the Web and the Net each and every day, and who will show this subcommittee some things that they do with the Web. I have already mentioned Dr. Toole from the HPCC Program, naturally enough, given his job. He has done some interesting uses of the Web.

On the second panel is Dr. Steven Running from the University of Montana, who will show us the use of the Web in analyzing satellite remote sensing data and disseminating that data to agricultural folks who use it. He is part of the forestry project in Montana, and of course when you come to talk about resource management on our public lands, I think this is going to be very important. I am happy to have somebody here from Montana anyway, today. It makes me very proud.

Second, we have Dr. Richard Gowen. Dr. Gowen is president of the South Dakota School of Mines and Technology.

Dr. Gowen has taken the lead on establishing a network on both the Web and the Net to help bring academic resources together with companies large and small in the plains States and other primarily rural areas, and we want to thank him for coming.

And third, we have Mr. Bill Burrall. Mr. Burrall is an award-winning teacher at Moundsville Junior High School in Moundsville, West Virginia, who uses the Internet in his classroom. He uses the Net for international communications among his students and people in other countries, and he makes a point of talking across international borders, and has tended to force his students to dramatically improve their writing skills. It seems that when we think of their words that might be going around the world, they tend to

care a great deal more about the grammar and punctuation, so we welcome him today.

All four of our witnesses will actually be showing Web home pages and some applications on the Internet and of course on the Web and what it can do.

Also, we would like to note that as we pass the telecommunications bill, and I think we finally will, we will be seeing much more of what we will be seeing here today, because I think what you are seeing here is probably the tip of the iceberg of what has been termed the new frontier, or cyberspace, but those frontiers obviously they get settled at one time or another, and we hope the telecommunications revolution that is going on in this country will allow us to reach out a little further.

So with that, I want to call Dr. Toole to the witness table, please, and hear from him, and then we will have some questions. Then we will get into some of the demonstrations of the Internet and the Web, and Dr. Toole, we appreciate you coming today, and welcome.

[The prepared statement of Senator Burns follows:]

PREPARED STATEMENT OF SENATOR BURNS

This hearing will now come to order. Today our Subcommittee will examine the "HPCC" program—the "High Performance Computing and Communications" program. This is the fourth year of federal support for the HPCC Program. As we review the FY96 budget request for the program, this seems an appropriate point to evaluate its progress and to revisit the question of the appropriate role for government in this kind of project. We also would like to see demonstrations of the "World Wide Web" that we've all heard so much about.

The High Performance Computing and Communications Program that we will be examining here today was established by Congress in 1991 to perform the fundamental research and engineering to enable American industry to build what everyone has come to call the "Information Superhighway." The program is intended to be as innovative as the technologies that this program is helping to develop. The HPCC Program is a program composed of activities funded in eight different federal agencies—NASA, and ARPA, and NOAA, and five others. These activities are coordinated by the National Coordination Office for the HPCC Program, which is part of the President's Office of Science and Technology Policy, headed by Mr. John Toole, who is here to testify before us today.

The HPCC Program has spent about $4 billion to date, and the Administration is asking Congress for $1.14 billion for FY96. A 1991 Act authorized the HPCC Program through FY96, so the Subcommittee must now begin looking at whether the HPCC Program should be reauthorized and, if so, at what level. Among the issues we are going to closely examine at the hearing today is: (1) what have we gotten for our money so far; (2) what activities are supported in the FY96 budget request; and (3) what does the Administration plan to do with the HPCC Program after FY96; i.e., do they plan to continue it?

In the second part of this hearing, we will be less concerned with oversight and more focused on simply looking at how these new computer technologies work. Politicians, myself included, have talked now for years about the benefits the information revolution will bring. Today, we will see their uses demonstrated by the people who actually rely on them. The information revolution may only be in its first phase, but it is here, and people in the "real world" outside the Beltway are using it for a myriad of applications.

Today we're going to see some of those applications. It is one thing to talk about the information revolution, or to give speeches about it, or to read about it in magazines, or to see stories about it on TV, but it is quite another to see someone actually using the Internet or the World Wide Web.

Today we have with us four witnesses, each of whom uses the Web and the "Net" each and every day, and who will show the Subcommittee some of the things they do on the Web. I've already mentioned Mr. Toole from the HPCC Program. Naturally enough, given his job, he has some interesting Web uses. On our second panel, we have with us today Dr. Steven Running of the University of Montana, who will show us his use of the Web in analyzing satellite remote sensing data and disseminating that data to the agricultural folks that use it. Dr. Running, I am happy to

have someone from my home state of Montana here today. Second, we have with us Dr. Richard Gowen. Dr. Gowen is the President of the South Dakota School of Mines and Technology. Dr. Gowen's university has taken the lead in establishing a network on both the Web and the Net to help to bring academic resources together with companies, small and large, in the plains states and in other primarily rural states. Doctor, thank you for coming. Third, we have with us Mr. Bill Burrall. Mr. Burrall is an award-winning teacher at Moundsville Junior High School in Moundsville, West Virginia, who uses the Internet in his classroom. He uses the Net for international communications among his students and people in other countries. He makes the point that talking across international borders has tended to force his students to dramatically improve their writing skills. It seems when they think their words might be going around the world, they tend to care a great deal more about grammar and punctuation. Mr. Burrall, we welcome you.

All four of our witnesses will be actually showing us World Wide Web "homepages" and some applications that the Internet and the Web can do.

I'd also would like to note that when we pass the Telecommunications Bill, that we will be seeing much much more of what we will see here today. Today the Web is the frontier of "cyberspace." But frontiers eventually get settled. The Telecommunications bill will help bring these benefits into the lives of all Americans.

Let me again welcome you to this hearing.

STATEMENT OF SENATOR HOLLINGS

PREPARE STATEMENT OF SENATOR HOLLINGS

I am pleased that the Science Subcommittee is holding today's oversight hearing on the Federal High Performance Computing and Communications (HPCC) program.

If ever we sought an example of how early Federal investment in key breakthrough technologies has paid off for both the government and the country, computing is it. Computers in general were born through cooperation between government, industry, and academia. And the Internet, so beloved by Members of Congress from both parties, started in the late 1960s as "ARPANET"—an experimental network created by the Defense Department's Advanced Research Projects Agency (ARPA). According to the Congressional Research Service, what is now the Internet consisted of two networks in 1983, 2,190 networks in 1990, and by March 1994 an astounding 28,578 interconnected computer networks! Millions of people now use that technology nurtured by ARPA, and that investment has given rise to an entire new industry—an American-led industry, creating new jobs and export opportunities for our country.

The Internet is an American success story, a combination of early and critical government investment, university ideas, entreprenurial genius, manufacturing and marketing know-how, and eventually an entire new market. But it is not the only example where government research investments have partnered with academia and entrepreneurs to build a better and more prosperous future for our nation. We have seen this story repeated in many other arenas—for example, agriculture, aircraft, biotechnology, semiconductors.

These points are worth bearing in mind as Congress considers proposals this year to severely cut or eliminate valuable technology partnership programs, including the HPCC initiative. Cutting these programs is cutting off a key part of our country's economic future. Make no mistake, such reductions will impoverish us, especially as trading partners continue their well-funded efforts to capture the key technologies and industries of the next century. The lessons today's hearing will bring out about the true roots of technological advance should be heeded by us all.

STATEMENT OF MR. JOHN TOOLE, DIRECTOR, NATIONAL COORDINATING OFFICE FOR HIGH PERFORMANCE COMPUTING AND COMMUNICATIONS, NATIONAL LIBRARY OF MEDICINE, BETHESDA, MARYLAND

Dr. TOOLE. Thank you, Senator, very much. I really appreciate the opportunity, particularly that this committee was so instrumental in the program from the very beginning.

I would like to take about 10 minutes, if I may, to give you some introductory remarks, and at the same time I would like to have Dr. Don Austin from my staff sit at the terminal, if that would be

acceptable. As we go through this, we are going to show you a little bit of the capabilities that we really have made available and are making available.

I am really excited myself. I have been in this job, the National Coordination Office for HPCC, as director, for a little over 2 months now, and I took over from Dr. Donald Lindberg, Director of the National LIbrary of Medicine, who served both jobs. I am the first full-time director and have spent the previous 9 years at the Advanced Research Projects Agency, which is a major key player of the HPCC Program.

Today, I really believe we have got an unprecedented opportunity to look at what the information future is going to be for all of us, and that is what I would like to talk about. It is central to our national security. It is our economic society, both socially and economically, and the leadership really has come from an extraordinarily complex—and we are going to get into this, I am sure, and some questions later—and fruitful long-term partnerships, between academia, industry, and Government.

Today's initial national and global information infrastructures that we talk about, the information superhighway that we are starting to see reaching out into the rural communities are based on technologies that are emerging from computing and communications research that has been underway for years. However, the dreams of tomorrow, I firmly believe, really rest with the investments we make in research today.

The Federal program has really been a model virtual agency across, now, currently, 12 Federal Government organizations concerned with high performance computing and communications research and development. The program has maintained an important balance between very long research science and engineering tasks and some of the most advanced computing and information technologies possible, all directed at the collective mission needs of the respective agencies and the needs of the Nation as a whole.

As we look to the future of information technology in the United States, I would like you to consider a recent report from the National Research Council. I do not believe that is on your dias right now.

The report, Senator, that you are holding in your hand, actually is the report for the fiscal year 1996, and that is what I am going to talk from, most of my testimony.

In addition to that, we have a National Research Council study done by Ivan Sutherland and Dr. Fred Brooks. We will provide that to you, but I think the point of this major study which was requested by Congress of the HPCC Program was really to establish what the long-term investment strategies need to be for the Nation made by Government and industry, and I am going to use some of that material as we go through the testimony today.

I would like to focus on three topics. First, some example key accomplishments of which we are only going to see a very short beginning of, and second a brief synopsis of our 1996 plan that you may have some questions on, and third where our future is. We will not dwell on the screen, and I guess we are not able to get it done right at the moment, but we will keep trying.

This report is also on line. It just came out this week, a report that we make every year that documents our accomplishments and our plans and progress, and I am very proud of this particular report, particularly having been only at the NCO for the past 2 months, but I think the effort highlights the 12 Federal agencies that contributed to it, and documents very nicely the variety and breadth and the capabilities that we really have.

In addition this has, you will notice, inside of it (and I think you will see demonstrated by some of the speakers that follow me) real links into the research organizations, so what we are attempting to do is empower the research community to provide more and more information and make that information available, which anyone here publicly or around the globe can access that on line right now as we speak.

A couple of examples might be useful just to highlight——

Senator BURNS. We are not going to get them, are we?

Dr. AUSTIN. I do not know what it is.

Senator BURNS. There is your billion dollars, folks. [Laughter.]

Mr. TOOLE. One example at the high end, if you will, were the spectacular images of the Shoemaker–Levy 9 comet fragments that were blasted around the television and the world, when some of the fragments hit Jupiter. It is really an example of brand-new scientific computational models run on a new generation of scalable parallel machines communicated almost instantaneously in the web of networks that was made possible in large part by some of NASA's Hubble space telescope, doing missions, if you will, that no one had ever foreseen at the time, and it coalesces from a systems approach many of these technologies that I think become very, very important to look at.

We have had interdisciplinary grand challenge research and development projects. These are computationally intensive projects, which have led to new science and engineering over a wide range of disciplines, modeling air flow, turbulence around aircraft, properties of their engines, combustion, ocean modeling, the atmosphere, the weather, pollution, climate, groundwater, earthquakes, vegetation.

All of these have been enabled by the ability to look forward into the future with computation and communications and be able to look at new scientific models. Processes and new science have really started to emerge from this type of activity. In addition, we have seen dynamics of car crashes and the evolution of galaxies. Innovation in high performance computing and communication techniques have really brought the Nation knowledge and capabilities.

Computational modeling has helped whole industries from new science and years later, and this is highlighted in the Brooks–Sutherland report, from the length of time it takes from the investment to the very interactive process that goes on between industry, academia, and the activities of investment to the fruitfulness of major markets that have actually developed.

In the future, I think we can expect new scientific results developed as part of the grand challenges that are combined with national challenges, which we refer to as information-intensive applications impacting U.S. competitiveness for societal well-being, which will greatly enhance the quality of life.

Weather forecasting, medical information are two examples. In the medical field, there are applications of telemedicine, which I know you have been briefed quite extensively on in the past by Dr. Lindberg. It is really becoming an important outreach aspect across the Nation. The National Library of Medicine has very important outreach programs looking at rural delivery of information in the West Virginia area, for example.

Networking, of course, has been an important component of the HPCC Program from its very beginning and its use, and probably will determine the future of where we are going. The success of the Internet is widely known, beginning with the early science, new ideas that came out of ARPA-funded research back in the sixties, to the NSF-funded activities which make this a very usable and deployable network capability linking research and education, and it has really made a difference for the country. For the research community and individuals across the Nation, it is providing public access to an incredible wealth of information that people see demonstrated here today, provided we can get that particular network up.

Also today you will hear some of the——

Senator BURNS. Basically I do not want to interrupt you, but when I learned how to use a computer I had to get my kids.

They will show you how to do it.

Mr. TOOLE. There is a lot of truth to that. That is the secret to success.

Senator BURNS. I did not know—I thought if you touched something the damn thing would blow up, you know. I guess it will not. The kids are not afraid of it.

OK, go ahead.

Mr. TOOLE. Many of the things in the networking arena that really have made a difference, and we are going to show you some of those things in Montana and South Dakota and West Virginia in the next session to see how the networking components have really made such a major difference. We have also supported Montana on a few things we have looked at and NASA, for example, has a component piece of funding Native Americans, outreach connecting those folks to a particular activity.

This is just one of many examples that occur throughout the program. A major activity in the HPCC Program has been the six gigabit testbeds jointly funded by all of the agencies to demonstrate the use of high performance computing. This was a way to look at the future and 9 agencies, 13 telecommunication carriers, 12 universities, 8 corporations, and 2 State computer centers have participated in these six testbeds, paving the way of what high performance use of computing technology would be for the future.

In many cases, science and technology has created opportunities for industry to open unforeseen markets and be at the forefront of technology in the 21st Century. High performance computing systems, software technology, and many other things have been part of the program, as is well-documented in our report.

The HPCC Program added a fifth component in fiscal year 1994, information infrastructure technology and applications. In the past 2 years, the program has supported research and development for the enabling information infrastructure and exploited the experi-

ence base that has grown from related research in high performance computing and communications.

One of the most notable achievements are the Web browsers that we are about to demonstrate to you when we are able to get up. The Web browsers were based on the Mosaic system developed at the National Center for Supercomputer Applications funded as part of NSF's HPCC Program, and already has a million copies licensed, and 10 million copies of other commercial versions, and probably a lot more in the industry.

The point I would like to make with that as an example, some of the early research that was really done as a result of the HPCC Program became the basis both from people transfer and technology transfer into the commercial industry, which is now an unforeseen segment of our industry that I think all of us can be very proud of that gives access to the rural communities as well as the Nation and the world as a whole.

Application programs as a part of HPCC Program refer to the experimental use of the advanced information technology research and development applied to real programs in innovative ways. The 4-year digital library that is jointly funded across HPCC agencies really leads the way to store, retrieve, research and process masses of information being gathered by weather satellites, sensor surveys, and many other types of relevant information.

Health care, national security, energy management, aeronautical design, public health, and education all benefit from the technologies of the HPCC Program.

Educational resources and computational tools are obviously a very strong part of the program and a very important part of our life. Students, including K through 12, undergraduate, graduate, and post graduate students can now approach difficult scientific and engineering tasks with a new set of computational tools that were previously not available.

They are able to study the human genome in high school, or lower grades now, and look at these things, the evolution of galaxies, design of new materials to be used for computational modeling.

Many of these projects, such as NASA's classroom of the future in West Virginia, are providing a new generation of educational modules and teacher support that use remote sensing data bases over the Internet, remote sensor data bases, for example, being collected from EOS as part of—and I think you are going to hear about EOS in subsequent testimony, so I will not go into that right now.

Finally, the HPCC Program has helped support a world class network of research facilities that are reaching out to the States, the localities, and individuals, and that is something that the program is very proud of.

I would like to move and very rapidly go through what our 1996 plan is, and just hit some of the highlights. I have submitted for the testimony some additional details, and I certainly could follow up with any other details if you would like.

Twelve Federal departments and agencies really participate in the HPCC Program now. The 1995 HPCC Program budget for the nine agencies was $1.0 billion. The 1996 request was $1.1 billion.

As you mentioned in your opening remarks, projects are competitively selected and include academia, industry, and Government labs.

Just to give you a rough rule of thumb, we did a back-of-the-envelope calculation and locked at some of the data and 55 percent of the program money goes to academia, 20 percent to industry, and 25 percent to Government labs, so to give you a flavor of the mixture of some of the recipients, it really spans a space that is very important.

In 1996, each agency's detailed program certainly is going to be submitted and briefed to the respective committees in addition to the supplement, the 1996 implementation plan, another document that we produced last year that gives very detailed information project by project, milestone by milestone, in different segments, which will be out this month, so you can look forward to that and I will be sure that we ship copies down to the committee.

While enormous progress really is now visible in high performance computing and communications in the first 4 years of the program, really much remains to be done. In my testimony, I have given you some ideas of the emphasis that we are doing in 1996 to prepare for the future, but I would like to move a little bit to some of our anticipated programs and come back to some of your initial comments, and then we can certainly entertain some questions.

The real information revolution, in our opinion, really is still in the future. The convergence of information, communications and computing and the technology associated with information technology are just now starting to merge and become viable. There is evidence of this if you look over and over through history at the technologies that are on the horizon. These, in turn, really fuel new systems approaches that have become very important to be able to put together and breakthroughs that open up entirely new possibilities.

The HPCC Program began during the Bush administration and received strong bipartisan support in both the House and Senate, and again, we thank this committee for taking the initiative, and it has taken the initiative, to be the very, very strong supporter of the important science base that this represents.

Since its beginning in 1992, the current administration has made it a priority for our long term science and technology investment, providing long term capability for the next wave of information technology while exploiting high performance computing and communications across the globe.

As part of the National Science and Technology Council, the Committee on Information and Communications Research and Development was established under the leadership of the Honorable Anita Jones, director of defense research and engineering, and the CIC chair, the Honorable Lionel S. Johns, OSTP, CIC cochair. The CIC has developed and published a strategic implementation plan titled, "America in the Age of Information," and I have provided a copy to you, Senator, and other members of the staff.

This plan, which is also an item I would love to show you in a few moments, outlines several strategic focus areas designed to really focus our fundamental information and communications re-

search and to accelerate development in ways that are responsive to the overarching goals, agency mission goals, and our Nation's long term economic and defense needs. The focus areas are global information infrastructure technologies, high performance/scalable systems, high confidence systems, virtual environments, user-centered interfaces and tools, and human resources and education.

Using this strategic implementation plan as a guide, we are engaging academia, industry, and Government to define the investments, beginning in fiscal year 1997, that will lead us into the information future. You will see this in two ways. First, each agency will submit their respective implementation plans and budgets through the committee structure and as a whole, and second, there is CIC planning activities which are now supported by the National Coordination Office which I now direct.

Sustained investment over the long term is essential, particularly with the inherent shorter term focus of industry.

It is hard to predict which new ideas and approaches will succeed, since the exact course of exploratory research cannot be planned in advance, and progress in the short term is difficult to quantify.

U.S. strength in information technology, economically and scientifically, is due in part to the aggressive Federal research investments in computing, communications, and mission applications of the agencies. HPCC is the initiative that has yielded leveraged cooperation, but the basic long term investment by the Government in this area is of vital importance to our future.

Mr. Chairman, I am acutely aware of the budget issues that face this committee and other committees of the Government today and our need to reduce the deficit spending sharply. I also believe, however, that information technology is our future, and Government investments we make in computing and communications will help shape our Nation's long-term ability to succeed.

I personally would not have taken this job 2 months ago if I did not strongly believe that these investments, coupled with the brilliant skills of academia and industry, are so critical to our future.

I know I have only given you some very brief sketchy highlights, but I would welcome your questions.

Thank you.

[The prepared statement of Mr. Toole follows:]

PREPARED STATEMENT OF DR. JOHN TOOLE

Good morning Mr. Chairman, Members of the Subcommittee, and staff. I am pleased to appear before this subcommittee and have the opportunity to describe the accomplishments, plans, and directions of the Federal High Performance Computing and Communications (HPCC) Program. I am very honored to have taken responsibility as Director of the National Coordination Office (NCO) for HPCC in March from Dr. Don Lindberg, who served concurrently as Director of NCO and as Director of the National Library of Medicine from September 1992 until March 1995.

After serving the past 9 years at the Advanced Research Projects Agency, I am now the first full-time Director of the NCO. I believe we have an unprecedented opportunity for establishing the foundation for America's information future and would like to talk to you about that today.

Information technology is central to our national security and to our society, both economically and socially. US leadership has resulted from an extraordinarily complex and fruitful long-term partnership among academia, industry, and government. Today's initial National and Global Information Infrastructures are based on technologies emerging from the computing and communications research that has been

underway for many years; however, the dreams of tomorrow will rest upon the investments we make in research today.

The Federal HPCC Program has been a model "virtual agency" since its inception, with unprecedented collaboration among the (currently) 12 Federal organizations concerned with HPCC R&D. The Program has maintained an important balance between very long term science and engineering, and the most advanced computing and information technologies possible—all directed at the collective mission needs of the respective agencies. Agencies have strongly supported the program because it is a complex field in which advancements are in their strategic best interests, and the most effective leverage possible grew out of this collaboration.

As we look to the future of information technology in the United States, I would like you to consider the recent study by the National Research Council, *Evolving the High Performance Computing and Communications Initiative to Support the Nation's Information Infrastructure*. This is a major study requested by Congress. In addition to looking at the HPCC Program in detail, the NRC committee of distinguished researchers from academia and industry studied the long term investments made by government and industry. This committee concluded that the government's investments in information technology have made a significant impact over the long term. The HPCC Program is the most critical part of that investment today.

In the short time I have today, I'd like to focus on three topics:

- Examples of key Program accomplishments that highlight new science, national capabilities, and future infrastructure,
- A brief synopsis of our FY 1996 plan, and
- Future anticipated activities.

Program Accomplishments

I am pleased to provide the committee copies of the report, *High Performance Computing and Communications: Foundation for America's Information Future*, which can also be viewed on-line via the World Wide Web. This report, prepared by the HPCCIT Subcommittee of the National Science and Technology Council's Committee on Information and Communications R&D (CIC), describes in detail the Program's significant accomplishments and outlines the breadth of the program. Although we have produced such reports every year, this year's report includes on-line links to many of the highlighted research projects, providing even more detail for the American public. I'll use a couple of examples to highlight some of the key investments that have been made since the Program's formal authorization in FY 1992.

The spectacular images transmitted around the world of the recent collision of the Shoemaker-Levy 9 comet fragments with the planet Jupiter illustrate the impact of HPCC technologies across multiple Federal agencies. It is an example of enabling new scientific computational models, run on a new generation of scalable computing systems, communicated almost instantaneously on a web of networks, that made possible the use of the NASA's Hubble space telescope in unforeseen ways. NSF's Pittsburgh Supercomputing Center and DOE's Sandia National Laboratories accurately foretold the event using new computational techniques that depend very much on high performance computing technology. These models provided the information for space scientists to point the Hubble telescope in the correct direction to observe first hand these unique events. Without the modeling efforts, a once-in-a-lifetime observational astronomy event would have been lost.

Interdisciplinary Grand Challenge R&D projects—computationally-intensive applications—have led to new science and engineering techniques in a wide range of disciplines. By modeling air flow and turbulence around aircraft, properties of their engines, combustion, the oceans, the atmosphere, the weather, pollution, climate, groundwater, earthquakes, vegetation, the human body, proteins, enzymes, the human brain, materials, chemicals, structural dynamics of car crashes, and the evolution of galaxies, innovation in high performance computing and communications techniques have brought the Nation new knowledge and new capabilities.

Research in computational modeling is starting to pay off, for example, in the US aeronautics industry. A comprehensive new engine modeling system called the Numerical Propulsion Simulation System, was developed under NASA using these techniques. It has resulted in engineering productivity improvements that enabled one of our premiere aircraft engine companies to cut design time in half for high-pressure jet engine compressors which are used in the Boeing 777. This new design also reduces fuel consumption—saving billions of dollars in fuel cost over the life of the fleet and reducing environmental impact.

In the future, we can expect that scientific results developed as part of the Grand Challenges, combined with National Challenges—information-intensive applications impacting US competitiveness and societal well being—will greatly enhance the

quality of life for Americans. Weather forecasting and medical information are two good examples. NOAA has developed a hurricane prediction system, using modern techniques requiring high performance computing, that can more accurately predict the path of a hurricane, provide earlier warning, and, in turn, save lives. In the medical field, application of telemedicine is bringing the physician instantly in contact with remote locations using advanced computer networks. Digital models of human anatomy are being developed to provide a new education tool for researchers, health care providers, students, and the general public.

Internetworking has been an important component of the HPCC Program, and will determine the future of the NII. The success of the Internet is widely known, beginning with ARPA—funded research in the 1960's and continuing to the NSF's privatization of the Internet today. For the research community and individuals across the Nation, the Internet ties people and places together to work on future challenges. It is providing public access to an incredible wealth of information some of which you will see demonstrated here today. HPCC research in networking is working to address the future capabilities, such as technical approaches for performance, scale, and security.

A major activity has been the six gigabit testbeds jointly funded by HPCC agencies to demonstrate the uses of high performance communications technology in actual agency missions. Nine Federal agencies, thirteen telecommunications carriers, twelve universities, eight corporations, and two state supercomputer centers have participated in these six testbeds that connect 24 sites. Asynchronous Transfer Mode (ATM) and Synchronous Optical Networking (SONET) technologies, developed rapidly in these collaborative projects, and prototype switches and protocols were developed to address issues at very high speed that would have taken many years longer without the HPCC Program. In many cases, science and technology has created opportunities for industry to open unforseen markets and be at the forefront of technology in the 21st century.

High performance computing systems have been essential to National Defense, NASA, NSF, and Department of Energy Scientists. The HPCC Program has funded research to explore new systems approaches and scalable techniques for a wide class of problems. For example, while we acknowledge the impressive world records in computation speeds, such as Sandia's 281 gigaflops linear algebra benchmarks performed on the Intel Paragon computers, research has been on-going on high performance backplanes, operating systems, embedded systems, networks of workstations, and new algorithms.

Software technology has always lagged hardware development. It is challenging to write complex computational models for many different machine architectures; however, languages such as High Performance FORTRAN and High Performance C++, along with software tools to support them, are available for use in new computational experiments. Software tools are now available to the public over the National HPCC Software Exchange, an activity supported by the HPCC Program to ensure rapid dissemination of advanced software to researchers throughout the US. Associated with the software development activities are new visualization techniques, such as the Cave Automatic Virtual Environment, which allows a user to explore new design approaches and unique ways to visualize the massive amounts of data today's researcher has available.

The HPCC Program added a fifth component in FY 1994, Information Infrastructure Technology and Applications. In the past two years, the Program has supported R&D for the enabling information infrastructure, and exploited the experience base that has grown from related research in high performance computing and communications. One of the most notable achievements are the "Web browsers" used to retrieve vast amounts of information available all around the world. Based on the Mosaic system developed at the National Center for Supercomputing Applications, funded as part of NSF's HPCC Program, already more than 1 million copies of public domain Mosaic software have been obtained through NCSA; more than 10 million copies of Enhanced NCSA Mosaic have been licensed through commercial start-up companies such as Spyglass, and there are many others such as Netscape, Spry, etc. This R&D activity at NCSA started an unforeseen segment of the communications industry, and spawned many commercial companies that will make global information accessible to all citizens and enterprises.

Applications programs as part of HPCC refer to the experimental use of advanced information technology research and development applied to real problems in innovative ways. These applications drive the HPCC technology development. By engaging in Grand and National Challenges in the HPCC Program, agencies have a unique opportunity to accelerate this critical technology into their mainstream. For example, the four-year digital library research being jointly supported by HPCC agencies will lead to new ways to store, retrieve, search, and process masses of in-

formation being gathered by weather satellites, census surveys, and many other type of relevant information. Health care, national security, energy management, aeronautical design, public health, and education all benefit from the technologies of the HPCC Program.

Educational resources and the computational tools that have emerged from the HPCC Program are an important result of this scientific investment. Students, including K-12, undergraduate, graduate, and post-graduate students, are now approaching these difficult scientific and engineering tasks with a new set of computational tools that were previously not available. These researchers, for example, are now capable of studying the human genome structure, the evolution of galaxies, and the design of new materials, by the use of computational modeling. Many of us believe that this Program is fostering a revolution in the way we do science, the way, we learn, and the way we share information. Projects supporting the classroom, such as NASA a Classroom of the Future in West Virginia, provide a new generation of educational modules and teacher support, using remote sensing databases over the Internet.

Even though some of the innovative computer manufacturers in the dynamic and highly competitive market of high performance computing and communications may fail, their insight into the nature of parallel computational algorithms and the structure of future computational systems did not fail. Indeed, they brought new knowledge and insight into the field of high performance computational science and engineering.

Finally, the HPCC Program has helped support a world-class network of research facilities that are reaching out to the states, communities, and individuals. I call your attention to the descriptions of the High Performance Computing Research Centers described in the FY 1996 Supplement to the President's budget that I have provided for you today. These Centers are actively engaged in research, education, outreach to minority institutions and rural areas, and training our next generation students throughout the US.

FY1996 Plan

In FY 1996, 12 Federal departments and agencies will participate in the HPCC Program by coordinating their R&D activities and accelerating technology transfer into key computationally intensive and information-intensive application areas. The estimated FY 1995 HPCC Program budget for the nine participating Federal organizations was $1,038 M. For FY 1996, the President requested $1,143 M for the 12 organizations. Projects are competitively selected and include academia, industry, and government labs. In FY 1994, for example, approximately 55% of the program moneys went to academia, 20% to industry and 25% to government labs/not for profits.

For FY1996, each Agency's detailed program is submitted and briefed to their respective committees. In addition to the supplement, a detailed *HPCC FY1996 Implementation Plan*, to be published this month, will provide a coherent overview of the detailed projects included across the 12 HPCC Agencies. While enormous progress is now visible in high performance computing and communications in the first four years of the Program, much remains to be done. Across the entire program, several new directions are being taken in FY 1996, based on research that has been ongoing in the program:

First, increased emphasis will be placed on research for all aspects of software for parallel, scalable computing systems, including software tools, compilers, operating systems, languages, development environments, and programming libraries. This will enable a new generation of application software developers, encourage independent commercial software developers, and stimulate new applications to meet mission needs.

Second, emphasis in the networking research areas will address new high performance protocols, "services" imbedded in the network, and ways to achieve an "open data network," as described in a recent report by the National Research Council. This will stimulate interoperable systems capable of interacting across the nation for many user's needs, and provide greater diversity among communications media, such as "wireless" and interactive cable systems for schools, libraries, health care facilities, and homes.

Third, research on innovative approaches to security, privacy, vulnerability, and reliability will be emphasized to enable information access and commerce. This includes all aspects of the system, as well as the critical networking areas.

Fourth, the Program will include demonstrations of advanced applications, combining the best of Grand and National Challenges. As we have begun to show, new discoveries in science and engineering are emerging, along with the infusion of this technology into the science and engineering base of the nation. In addition, capabili-

ties of the future information infrastructure are already being demonstrated. Applying these technologies to our Nation's most important problems, in conjunction with other National programs, is a mechanism to achieve enormous leverage of Federal funding of R&D while advancing our overall quality of life and our country's economic competitiveness for the 21st Century.

Future Anticipated Activities

The importance of information technology to everyone in the US has become evident, but the real information revolution is yet to come. Capabilities double every 18 to 24 months, thanks to the enormous progress in microelectronics and components. These, in turn, fuel new system approaches and breakthroughs that open up entirely new possibilities.

The HPCC Program began during the Bush Administration and received strong bipartisan support in both the Senate and the House. Since its beginning in FY 1992, the current Administration has made it a priority for our long term science and technology investment, providing long term capability for the next wave of information technology while exploiting high performance computing and communications across the globe. The National Coordination Office, which I now direct, was created to coordinate the Federal HPCC Program across the Federal government.

As part of the National Science and Technology Council (NSTC), the Committee on Information and Communications R&D (CIC) was established under the leadership of the Honorable Anita Jones, Director of Defense Research and Engineering and CIC Chair, and the Honorable Lionel S. Johns, Office of Science and Technology Policy, CIC co-chair. The CIC, which consists of senior representatives from R&D Agencies, has developed and published a strategic implementation plan titled *America in the Age of Information*. This plan outlines several strategic focus areas designed to focus fundamental information and communications research and to accelerate development in ways that are responsive to NSTC's overarching goals, agency mission goals, and our Nation's long term economic and defense needs. The strategic focus areas are: global-scale information infrastructure technologies, high performance/scalable systems, high confidence systems, virtual environments, user-centered interfaces and tools, and human resources and education.

Using this strategic implementation plan as a guide, we are engaging academia, industry, and government to define the investments beginning in FY 1997 that will lead us into the information future. You will see this emerge in two ways—first as each Agency submits their respective implementation plans and budgets and, secondly, as part of the CIC planning activities, which are now supported by the NCO.

Sustained investment over the long term is essential, particularly with the inherent shorter term focus of industry. It is hard to predict which new ideas and approaches will succeed, since the exact course of exploratory research cannot be planned in advance, and progress in the short term is difficult to quantify. Furthermore, the industrial R&D investment, although much larger than government investment, is very different in nature, necessarily focusing primarily on shorter term product development cycles. The rationale for government investments in this crucial area are developed in detail in the NRC HPCC study and the other documents cited.

US strength in information technology—economically and scientifically— is due in part to the aggressive federal research investment in computing, communications, and mission applications of the Agencies. HPCC is the initiative that has yielded leverage through cooperation, but the basic long-term investment by the government in this area is of vital importance to our future.

Summary

Mr. Chairman, I am acutely aware of the budget issues facing this committee and the need to reduce our deficit spending sharply. I also believe, however, that information technology is our future, and government investments we make in computing and communications will help shape our long term ability to succeed. I personally would not have taken this job if I didn't believe so strongly that our investments, coupled with the brilliant skills of academia and industry, are so critical to our future.

I know I have only given you some of the highlights of the program, but welcome any questions or comments from the Committee. Thank you for this opportunity.

Senator BURNS. Mr. Toole, as we work our way through this, I know you have got some things, and maybe we can iron out some bugs in that thing, but I want to call the second panel up, and then we are going to look at some demonstrations, and I want to ask you

some questions with regard to the budget, where you want to go from here.

What we have gotten for our money so far, and I think you have gauged it right, because we are in times of great budgetary stress, and where we are looking at programs now in trying to come up with a budget message that is going to have some real hard numbers in it, and we are going to have to search our souls and set some priorities and exactly determine where we want this country to go, whether it be in food security and safety or our high tech industries, and those Government services that tend to support the people of this country.

So every time I see a question, if it is a Government investment, it is America's investment, it is the taxpayers of America that invest in these things, and I think they deserve some answers on what are we getting for our dollars.

So with that, I want to call up Dr. Bill Burrall from West Virginia, and I think he has some testimony, and I want to start with him, and also Dr. Richard Gowen and Dr. Steve Running, and I want to see some of this, of what they are doing with the support of Mr. Toole and his organization and this computing, and then we are going to go back and I think it will lay it out a little bit better on some of the questions that I have to ask Mr. Toole.

And it also would give a little bit of time for the rest of the Senators who do not go to work until way up in the middle of the day to get here, and maybe ask some of their questions.

So with that, Bill Burrall, thank you for coming from West Virginia. You did not have very far to come. We appreciate—and pull that microphone in to you, and we are ready for your little demonstration and what you want to show us, if we possibly can.

Mr. BURRALL. We are waiting for a connection problem.

The software seems intact, but it is a physical problem with the connection, and they are working on it. Hopefully we can get this link up.

Senator BURNS. And is that also, it affects all of you?

Mr. BURRALL. Exactly.

Senator BURNS. We may have to bring up Mr. Toole again and ask some questions, and why do you not take the chair down the other end of that thing there. [Laughter.]

Senator BURNS. Until we get somebody fooling with it and getting it going, just sit tight real quick, and Mr. Toole, the program was initiated in 1991, and at that time it was set up to be a 5-year program, of which we are going to take a look at reauthorization now. We are just now coming up and taking a look at our budget and, of course, we know this is important, yes, but where do we put it on the priority list, and so I guess my question is, from the administration standpoint and from your standpoint, where should we be going with this program, and do you have specific plans and goals on how we are going to get there?

Mr. TOOLE. Thank you for asking the question, Senator.

I am very happy to provide you with where our thinking is now.

As far as the administration is concerned, this is still a very, very high priority project. The "America in the Age of Information" really defines what the long term 10, 15 year strategy needs to be and the kind of investments we think are really going to be critical.

The initial authorization for a 5-year program was the goal of where that first block of investment needed to be.

This program is different in a couple of respects, and I would like to make that point very carefully. Each of the agencies—this is not—I do not direct, OK, and manage the program.

I really coordinate the activities very carefully between each of the respective agencies that participate. Information technology and communications is embedded in virtually every program that probably comes before this committee or any committee on the Hill. It is fundamental. The investments that we make here have enormous leverage.

While we look, for example, at the dollars that we have been spending, we are talking about half-a-billion dollar industry, maybe $1.5 trillion industry, almost in that range of activity in the outside marketplace as people look at it.

The thing that is very unique about science and technology investment is really the long term goal, and if you look at how that investment has been made, I think you find that the industry investment, while one could argue in numbers maybe around $20 billion, depending on some of the dollars, the percentage of that number that really is for the long term is very small.

And the coupled nature of the academic world, to give you the best and brightest activities—in fact, we could even go through the Mosaic browsers, for example. The people that were actually trained years ago were the people that are now the CEO's of those companies. There are people that were involved in the computing technology field that emerged from the science and technology.

As far as where the administration is going, we have produced the strategic plan. We are working with each of the 12 agencies or other agencies across the Federal Government to prioritize, to scrub through these and see what impact this is really having on each of their mission agencies, and it has had an enormous impact.

That is why it has been so high priority for as long as it has been, and we believe it is going to continue in a revitalized, reinvigorized way for the future, focused on the information future and the kind of activities that are going to be so important to broaden the base of technology and to combine the high performance aspects which are also critically important to our future, but the information infrastructure parts of it.

Senator BURNS. You have been working, of course, and other people have been working in this program for now 5 years, and I realize that whenever money is invested on a startup program there are certain building blocks that have to be in place before you can do other things.

Give me an idea, now, if we go through and we appropriate again another $1 billion for this program, we reauthorize the program maybe for another 5 years, will that money be spent on different things? Where do we go from here? Is the basis there to do other things? Have we completed what we wanted to complete in the first 5 years? Is the foundation now there to go beyond now, and give me some idea of vision that we might have for the next 5 years.

Mr. TOOLE. Let me by analogy just back up for 1 second, if I may. Prior to the establishment of this program, there was a long-term investment strategy of sorts that became a baseline that en-

abled us to define where the next wave would be, i.e., the basic HPCC Program. That was actually created in fiscal year 1992.

The fact that we had a track record of success over the longer term allowed us to take those efforts and to put them together in a real concept across the agencies for this 5-year period to develop scalable technologies and high performance computing and communication that would really be successful for the long term.

Science and technology cannot be totally predictive in the sense some things are very serendipitous, and you have got to allow for that flexibility in the investment structure and, indeed, an example of that has been the Web browsers that you see today. There is an example of something that we could not have predicted if we had been called on the carpet and say tell me the five milestones that one would have, but the fact that we have developed an infrastructure and developed the specific technologies that can produce real products over a period of time become very important.

Now let me shift to the future. We, I believe, have a tremendous track record of success of production and capabilities from the new science. The capabilities we have had—again, I apologize for not being able to show those to you on line, but they are all well-documented here and I will take the opportunity if you give it to me to show you personally those kinds of activities.

If we look to the future of where the information revolution is really headed and from the R&D components I think we have tried to characterize those investment strategies along those six strategic focus areas, each of which represent very important mechanisms for the future.

I would anticipate, for example, under the purview of the Committee on Information and Communications, we have been talking about roughly in the area of about a $2 billion investment, HPCC being the center part of that investment in today's structure.

We are looking to restructure that in a more effective, synergistic way with what the agencies are, and that is what we are going to come back to you, from the agency and the committee structure, where the future is going to be for the fiscal year 1997 budget as we see it.

But I think if you look at the year 2010 and beyond, the kind of activities that you need, given the very dynamic nature of the business, given the very dynamic nature of the research and technology that is emerging in the marketplace, we have got to be prepared for the next wave of scientists, engineers, information technology, and how we can distribute that to the individuals in the Nation.

Senator BURNS. With that, the building blocks, and we have learned some things as we have gone along the way, and I have just—there have been some folks that have been fairly critical of our parallel computing developments, those efforts there, citing the collapse of the parallel computing industry as hard data from the marketplace and the research community that the parallel computing paradigm has failed the crucial test of usefulness to actual, real world users.

Industry and researchers have moved instead to use the new high powered and less costly engineering work stations that are also easier to program than parallel computers.

I think I first picked this up when I was visiting Boeing about a year ago and watched the development of their 777, and I was asking some questions about it, because this is the first airplane that has been built by a computer model, and they built no mock-up or prototype, and by the way, the lead engineer on that was just an old cowboy kid from Roundup,

Montana, and Steve, you might be interested in that, and by the way, to brag even further, the man that is in charge of manufacturing and assembly of the 777 is a wheat farmer from Chester, Montana, so us farm kids——

Mr. RUNNING. We are taking over.

Senator BURNS. Well, I know it. We are. [Laughter.]

Senator BURNS. They are afraid of that out there. [Laughter.]

Senator BURNS. You might want to—should the HPCC Program back away from parallel, that sort of—that computing research? Should we back off from that? Have we learned enough?

Mr. TOOLE. Absolutely not, Senator. I think what we are going to find, and let me put it in context, because I believe what gets reported typically in the press sometimes is a little bit of things that are out of context. The whole program itself funds——

Senator BURNS. You could go into politics.

Mr. TOOLE. No, sir. [Laughter.]

Mr. TOOLE. No, sir. But what has really happened is the fundamental evaluation of what is happening in the computer work station industry is the Net result of much of the research that was funded out of the high performance computing and communications program, the work station component parts of it, the high performance backplane, ATM, SONET technologies, things that are really now commonplace words in industry but not 3 years ago, were seed money funded from a lot of the activities in this particular program.

Why does that become important? Backplane technology, software technology, it becomes important when you try to put these together in a real system.

Now, what does this mean? From a very high end, parallel, massively parallel machine, I believe the research that we have funded has solved many, many real problems.

I was speaking last week to someone from the oil industry who said, oh, we just bought another CM–5. He said, well, it is making money for us, OK? There are industries, in the auto industry, in the oil industry, that parallel machines even currently that exist are making enormous impact.

Now, let me go into a little bit of what I believe is important from the science and technology arena. The program must look at a diversity of capability. We are not producing a machine. We are not producing one teraflop machine, say, we are done, and it is over. That was never our strategy. It was a metric to look at as we go forward.

What was important was to develop the technologies, distributed systems, that came out of this program that is allowing us to do the kind of things you are going to see demonstrated hopefully sometime today that really becomes important.

Now, let me comment, if I might, on the software issue, because I think these are very hard problems, parallel systems. Before, the

parallel systems were aloof from the individual researcher. Now, thanks to microelectronics, thanks to high performance backplanes, our work stations can have enormous power.

Guess what that does for us in the high performance computing world? It allows parallel processing now to be at the desk top level, OK, and the next wave will be, if we have parallel processing and are able to go to performance and distributed capability, that is where we want to be able to be headed.

So to conclude and wrap it up—I was a little bit long-winded here—1) I think the fundamental research that we have invested in, all the agencies together, and demonstrated, clearly have been absolutely in the right direction for the future, that we have done. This has been validated by the National Research Council Study, who gives strong support for the investment technologies that we have had.

2) Parallel computing and scalable technologies, if we look at it, it is how do you apply diverse, distant, long latency kind of issues across the Nation, across the world, to a class of very, very important problems, and that is the nugget that still becomes fundamental. It is a very hard problem. It requires very high computation.

But what we want to be able to do is that the people in your State should have access to the materials that are generated by the world's fastest computers. The Intel Paragon, recently, we won, if you will, from a high performance point of view, 280 gigaflops of two machines put together, the world record, if you will, on a Linpack benchmark.

That may not mean much to the common individual, but what you start to see being produced by some of the scientific ends is material that can actually be used in different ways to a wide distribution, so the question, I think, raises the issue of what is the wave in generation? It is a technology system.

It is not just one focus over time. It is looking at component technologies, system technologies, a fair amount of applications that make sense, that make this real, and a vision of where the future is going to be.

If that is what our goal is in the kind of programs that we can do and engage academia and industry for the long term in, what we have created is a way to go to another generation of class machine and technology, and the technology and software technology that have.

I will say these problems are extraordinarily difficult, and I am not afraid to say that, because if they were not we should not be doing it, and I am proud to say that the people and the researchers and the program have really moved forward and while software always lags hardware, I think we are really seeing the opportunities now for the future really develop in very, very substantial ways.

Senator BURNS. This young man comes in here with his face full of hope and promise. Let us see how he is doing here. Have you got it going?

Well, let us go. Why do you not respond, Mr. Toole—uh-oh, we may be getting somewhere here.

Mr. TOOLE. I think we are there, Senator.

Senator BURNS. That is like what the little boy said when the ferris wheel broke loose. He said, now we are getting somewhere. [Laughter.]

Senator BURNS. I will tell you what, I have got a couple of other questions, and one of them is, it is sort of a touchy thing about the 1993 report of CBO that brought out some tensions that are happening within the organization, and we will discuss that.

While we have got the connect-up we want to get Mr. Burrall here on line, and I want to welcome also the Ranking Member of this committee, and a gentleman that I have had the opportunity to work with over the last 6 years when he was chairman of this committee, and a very able chairman, and I would ask if he has any comments before we ask his representative from West Virginia to explain and show us what he is doing in West Virginia.

STATEMENT OF SENATOR ROCKEFELLER

Senator ROCKEFELLER. Thank you very much, Mr. Chairman,

I am very happy to have an award-winning teacher from Moundsville, West Virginia, here, Mr. Burrall, who either now or later will describe what is going on in his school. In fact, let it be said that we have an extremely high fiber optic component in West Virginia. Bell Atlantic has been very, very aggressive from the beginning. And I think we really rank right up at the top in terms of fiber optic capacity for elementary schools and junior and secondary schools.

And so it is a future full of hope for a State that needs all of the educational advantages that we can get, and this is a big one. So I am just very proud that Mr. Burrall is here.

Also, I have a statement to submit to the record, Mr. Chairman.

Senator BURNS. Without objection, that will certainly be made a part of the record.

[The prepared statement of Senator Rockefeller follows:]

STATEMENT OF SENATOR ROCKEFELLER

PREPARED STATEMENT OF SENATOR ROCKEFELLER

Mr. Chairman, I want to commend you for holding this hearing and particularly for inviting witnesses from the states. For today's subject—high performance computing—is an outstanding example of what can happen when the Federal Government helps universities and entrepreneurs develop a new technology and then people in the states and industry run with that technology. From humble beginnings at the Defense Department in the late 1960's, computer networking has exploded into a major tool throughout the country for improving education, health care, and manufacturing. It also has become a major industry in which our entrepreneurs lead the world, creating new jobs and new export opportunities for the United States.

This hearing is particularly timely, I believe, given that Congress is now engaged in a major debate over Federal technology programs. Some Members have proposed cutting or even eliminating technology efforts such as the High Performance Computing and Communications Program.

Yet if the government walks away and does not support our country's best minds, where will new basic technologies such as the Internet come from? Even large companies are increasingly forced to focus scarce research dollars on projects that pay off quickly. And small entrepreneurs still need university ideas and research support from agencies such as the Defense Department and Commerce Department. If government seed funds go away, so does much of this nation's long-term investment in new technologies, new industries, and new jobs. The country prospers when the Federal Government, academia, and entrepreneurs work together. That is one of the key lessons of the Internet story.

The other main lesson of the Internet is the incredible imagination shown by people in the states. The Internet and new Internet tools such as the World Wide Web are now being used in ways only a few could imagine in past years. And today I look forward to seeing the demonstrations prepared by the three experts on our panel.

I want to particularly welcome Bill Burrall, an award-winning teacher from Moundsville Junior High School in Moundsville, West Virginia. Bill's students have used the Internet to communicate with young people in Japan, Korea, and elsewhere. They use the Internet's World Wide Web to open up new worlds of information. Most of all, they are learning skills that will prepare them and West Virginia for the 21st century.

Bill Burrall's activities are part of the exciting effort West Virginia is now making in information technology. For example, our governor has made a pledge to put computers and local-area networks over the next 10 years into all classrooms from kindergartens through sixth grade, for a total investment of $70 million. So far, all elementary schools have computers—1,500 in total—and 8,600 West Virginia teachers have learned how to use computers in the curriculum.

In addition, the West Virginia Department of Education has 50 pilot schools on the Internet, mostly secondary schools. Some 1,600 teachers have Internet addresses and training on the system. The Internet links and teaching training are supported by $6.9 million from Bell Atlantic, $2.9 million from a National Science Foundation grant, and $2.5 million from a U.S. Department of Education grant to the West Virginia Library Commission.

We also have 320 satellite downlink sites, allowing some 900 students, mostly in secondary schools, to participate in distance-learning courses in foreign languages, chemistry, and college advanced placement. Without distance learning, a rural state such as West Virginia could not offer this range of courses to its students. And we have 30 sites so far for advanced multimedia education.

Mr. Chairman, I am proud of what my state and yours have done with these important new computer and educational technologies. And I am proud of the Federal role in first helping develop the new technologies and then in working with imaginative state officials and teachers to bring the fruits of these new technologies to our communities and citizens. This is an American success story, and we should congratulate those who have made it a reality.

I look forward to hearing from our witnesses and seeing the demonstrations, and I once again want to commend you, Mr. Chairman, for holding this important hearing.

Senator BURNS. The chairman of the full committee has just arrived.

STATEMENT OF SENATOR PRESSLER

The CHAIRMAN. I will not take but 30 seconds to welcome a South Dakotan, Dr. Gowen, who is the president of one of our universities. We are very proud of you. I have a statement about all of your attributes which I will put in the record, because it might overwhelm my colleagues if I were to read it. [Laughter.]

[Prepared statement of Senator Pressler follows:]

PREPARED STATEMENT OF SENATOR LARRY PRESSLER

Chairman Burns, I want to thank you for holding this oversight hearing on the High Performance Computing and Communications, or "HPCC" Program. I think oversight of this program is long overdue, and I commend you for taking a good, hard look at it. I also am looking forward to actually seeing some demonstrations of the World Wide Web Computer Network later in this hearing.

Mr. Chairman, we in Congress have been constantly told that we are heading toward the creation of an "information superhighway." Well, I disagree; I do not think "the highway" metaphor is very useful in thinking about the electronics and information technology revolution we are now experiencing. What is actually occurring is not the construction of a highway, but instead a convergence of various information and communications technologies as all media become digitized; that is, reduced to the ones and zeroes of computer language. TV, CDs, radio, telephones, faxes, data are all now digital. Sound, text, and pictures all have been reduced to the same medium.

In addition, Mr. Chairman, the means by which these ones and zeros move from place to place are getting much faster and capable of carrying more along their

paths than ever before. All of our communications media—fiber optic cables, microwave radio, cellular, coaxial cables, high orbit satellites, low orbit satellites—are becoming interconnected and intertwined and transparent to the user.

Mr. Chairman, we owe all this technological dynamism to our free market system. Look, for example, at telephone communications. Much of the dynamic growth and development we have seen in telecommunications in recent years is specifically due to the talent and skills of visionary entrepreneurs. Mr. Chairman, look at Silicon Valley. Silicon Valley is a place where two young men in a garage could start and build a multi-billion dollar business based on technical innovation. We hold up Silicon Valley and its various success stories as our prime examples of entrepreneurship as a value. Ted Waitt, the founder of Gateway 2000, a computer company in my home state of South Dakota; Bill Gates; David Packard; and all the other high-tech pioneers were able to build their companies and the technological innovations they created, because they were empowered by our free market system. This is because information technologies were, as a rule, the business area least encumbered by government regulation.

Mr. Chairman, I would note that highways are built by governments; but telecommunications networks have been built by private companies. It is my belief, Mr. Chairman, that S. 652, the Telecommunications Competition and Deregulation Act, by helping to open the free market, will greatly hasten the advent of the total media and information convergence that we see happening all around us.

Let me also take this opportunity to welcome to our Subcommittee Dr. Richard Gowen, President of the South Dakota State School of Mines and Technology. We in South Dakota are very proud of Dr. Gowen's innovative applications of computer networking in education and research. I look forward to his demonstration of some of those uses in the second part of the hearing.

Thank you, Mr. Chairman.

Senator BURNS. He comes from an overwhelming part of the State of South Dakota. He is close enough were we could almost claim him in Montana. [Laughter.]

Senator BURNS. Mr. Burrall, thank you.

Are you done?

The CHAIRMAN. I am done.

Senator BURNS. Thank you for coming. We appreciate that.

Mr. Burrall?

STATEMENT OF BILL BURRALL, MOUNDSVILLE JUNIOR HIGH, MOUNDSVILLE, WEST VIRGINIA

Mr. BURRALL. Thank you very much. First of all, I want to thank you for calling me Dr. Burrall. The first thing I will do when I get back is inform my superintendent I am in line for a pay raise. [Laughter.]

Mr. BURRALL. I would like to direct my comments this morning to some brief statements before I get up and do some demonstrations, and really thank Tim and his staff for getting the system back online. I know we are all sitting here a little nervous because we do have a wealth of information to show you.

In reference to your question, Senator Burns, about are we getting our money's worth, I am going to direct my comments from the classroom teacher standpoint and what we are doing in the trenches and what is happening in education, not only in West Virginia, but States such as Montana, South Dakota, and globally, from the perspective of a teacher and students using this type of connectivity.

Cyberspace is another name for the World Wide Web or the Internet. The definition was written sometime back by an author whose name eludes me right now, that cyberspace is a fictional environment where humans and computers live and work together. Well, in case no one has noticed, it is no longer fiction. It is essen-

tial that we work with computers in the global marketplace to survive nowadays.

The Internet also has been labeled as the largest functioning anarchy in the world. Nobody controls it. It is new, it is evolving, and what is scary is, it is in its infancy right now. 25 years ago it began with ARPAnet. A lot of people do not know the Internet is 25 years old. Back then, I believe there were two computer servers that consisted of the Internet, and right now there are over 2.5 million servers worldwide that connect the world in all aspects.

As far as importance to education, and I am going to elude my comments also to what Mr. Toole said about preparing students for the workforce, we have to prepare students to be competent in technologies, not only telecommunication technologies, but all types of interconnected computer applications, the list could go on and on. I have a list that I kept here as sort of an outline, and my biggest problem in coming here was keeping this list on what this is doing for education to one page instead of 100 pages.

The connectivity that we are experiencing with this type of connection, is running at a 56 kilobyte connection here today. There are faster ones, the T–1 line which is exponentially faster than this one, but this does a nice job.

It is what we have in West Virginia. As Senator Rockefeller mentioned, Bell Atlantic has been very aggressive, and over the next year and a half to 2 years plans on putting this connection you will see here, in 800 schools in West Virginia.

Presently we have, I believe, 63 schools online. It is growing every day. I was fortunate enough to have the first connection in the State, and we have evolved tremendously just in the short time we have had the connection in our classroom.

What it does to education, it allows students and teachers to overcome the boundaries of time and distance.

They no longer exist. They mean nothing anymore in the classroom environment. We can visit countries, we can visit just about anywhere we want, just with a point and click of the mouse. Students can go on electronic field trips. If we need to go view the Dead Sea Scrolls, I can take you there in a matter of seconds, here in a few minutes. We have instant access to current information in thousands of data bases, not only within this country but worldwide.

For the student, it enhances academic performance and achievement and technology skills, all critical in line with the Goals 2000, the national goals, preparing students for the workforce. It enhances professional development of teachers.

I have seen and experienced personally a tremendous amount of professional growth, and colleagues of mine that work in my building are doing the same, winning national awards. We have two other people in our building that have gleaned national awards due to their work in telecommunications.

For me, the biggest change in the way I teach and they way my students learn came with telecommunications. We have been connected for the past 7 years. The most important change in my teaching career came when I had a phone line installed in my classroom. Back then there were 1 percent of the schools in the

country that had that. Presently there are 3 percent. It needs to grow.

We started with a 300 baud modem, and advanced to a 1200 baud, then a 2400 baud, and now we have, a phone line connection, at 14.4, which is fairly fast, but not near as fast as what you will see here today. The projects we were doing on line at those low connection speeds prove that educators in this country and students in this country can interconnect throughout the world and really gain a lot from making connections globally.

We did a project a couple of years ago. This project ran 3 years from its inception. We had the State maximum security prison four blocks from our school. They have a modem at the prison, and they have an education department. Ironically, their bulletin board service is called the West Virginia Playpen. We connected to them, and they chose 12 inmates.

These guys were not boy scouts.

We also were connected to a smaller network than the Internet, and I say smaller in jest. This network is 50,000 students in 22 foreign countries. It is the AT&T learning network. Students from those countries E-mailed us questions to our classroom, where my students served as the focal point and forwarded those questions to those 12 inmates, 6 of which were in for life, no chance for parole. They gave candid accounts of their life in prison, sent them back to us, we literally sent them out to the world, and they reached 22 foreign countries, and a 50,000 student base.

That was a project we are quite proud of. It is documented in the Smithsonian Archives, and won national and international awards.

With this connectivity, we are ensuring to provide the highest standard for our students in learning. It provides benefits to all students. We can also go to a site, if we have time, that is at the University of Kansas called SPED online, special education, students with disabilities, resources there for teachers on how to handle students with disabilities. We have unlimited and untapped resources that are out there now, available to us.

The technology that is now in reach, is in reach of communities and libraries across this country. It is critical that we receive and continue to receive support and funding, because our life blood depends on that. I have some charts here that I will give you that I would like you to share with your colleagues that show the growth of the Internet and the greatest number of people who are connecting to it right now are the educators, closely followed by commerce and businesses.

This connection is appearing more and more in homes as costs become reasonable, and with the advent of ISDN, when it comes into the home market it is going to revolutionize learning at home. It is literally going to revolutionize learning, and we will be running home connections which will be faster than what you see here today.

[The prepared statement of Mr. Burrall follows:]

PREPARE STATEMENT OF BILL BURRALL

Honorable Senator Conrad Burns and members of the committee,

It is an honor to have been asked to give testimony to issues concerning the "affordable school/library telecommunications access" amendment.

As a classroom teacher, I have been utilizing telecommunications and online services in the classroom arena for the past thirteen years. Our classroom connection has evolved from the 300 baud modem to 56 kilobit frame relay access which supplies us, at present, with a high-speed connection to the Internet. The level of access we presently possess provides my students with a window to the world and places at their fingertips a world of learning opportunities never before thought possible. Connectivity such as this becomes a most important issue for schools such as ours, located in rural America. Presently, only three percent, or one out of every four schools in our country have classroom access to the Internet at varying levels of connectivity. To ensure equal opportunity to all students and citizens, I cannot emphasize enough the importance and need for the government to expand and maintain the transport medium and ensure affordable access to educational institutions and libraries across the country.

According to Information Week, in the past ten years alone, the use of electronic mail has grown from 300,000 users to over 6 million. Prodigy and America OnLine are registering record numbers of new users, all wanting access to lanes on the Information Superhighway. Elimination of vital funding sources for the nation's educational infrastructure would seriously impair our ability to prepare our students for the 21st century. In short, our nation's children stand to lose a great deal in respect to their future. This loss of opportunity to become productive citizens will also impact future generations in respect to the stability of our nations retirement system.

The three R's have now evolved into the four R's with the addition of information "Retrieval" as a most important skill necessary for survival in today's competitive marketplace. Information retrieval skills become even more important when one looks at the global picture. Equitable and affordable access to the Information Superhighway will assure that our nation is providing unprecedented learning opportunities for our children in a society that requires its citizens to be technologically literate as they compete in a highly competitive global marketplace.

I have experienced, firsthand, students and colleagues that have had their lives greatly enhanced and become more effective learners through the use of online services. My students have become members of the global community with their electronic visits to classrooms throughout the United States and around the world. Throughout the past two weeks we have been interacting with a school in Oklahoma City and receiving candid accounts from a teacher whose assistant principal's husband is still one of the missing. Realtime learning through technology! We have hosted numerous collaborative learning projects and participated in global events, such as the recent World Summit for Social Development in Denmark in which my students sent essays to world leaders. Over the years from our classroom in rural West Virginia, we have visited and worked cooperatively with students in Japan, Germany, Korea, The Netherlands, Bermuda, and even the remote town of Akutan, Alaska...population ninety-five. The Akutan example solidifies the point that universal access is of paramount importance to ensure that all students in the K-12 arena have such opportunities. On a remote island in the Aleutian chain, telecommunications became a vital link in the lives of those students and residents and literally brought the world to their classroom and community.

It was through online services that my students took their peers from across the country and in far off lands, behind prison walls to take a candid look at society's problems in a project that gained international acclaim and a place in the Smithsonian archives. In this project, students had the opportunity to ask questions to inmates incarcerated in our state maximum security prison. The results were dramatic and touched the lives of students, teachers, and communities in twenty-two foreign countries. One outcome of this project was the honor I received as 1993 National Technology Teacher of the Year. Collaborative classroom projects like these are taking place on a daily basis on the Internet and enable students and teachers to transcend the barriers of distance and time in creating new and exciting learning environments.

I have found that students who participate in online projects show a dramatic improvement in their reading and writing skills. When students write for a global audience, they seem to focus not only on what they say, but on how it is presented to their peers. Likewise, teachers who use information services also show enhanced professional development and enhanced teaching skills and strategies in integrating such technologies into the curriculum. Telecommunication technologies are enabling teachers to become the agents of change rather than the objects of change, and motivating students to take control of their own learning.

Although the Internet has been around for some twenty-five years, its evolution in the educational arena is in its infancy. I firmly believe that as it evolves, it holds the potential to be the single-most important teaching tool to ever arrive on the edu-

cational scene. It is changing and will continue to change the way teachers teach and the way students learn. Students and teachers alike now have access to world leaders, experts in their field, not to mention the wealth of informational databases that presently exist and continue to grow on the Internet daily.

It is of extreme importance that as students, teachers, and the entire educational community merge onto the superhighway, they do not encounter toll gates as a barrier to learning opportunities. Barriers which will further widen the gap between the have's and the have not's. To have access to the Information Superhighway is to have an open passport to travel the world, visiting libraries with a lifetime library card and no return date necessary. Loss of this opportunity for lifelong learning would be undoubtedly a great injustice to the educational community and the citizens of the greatest country in the world.

On behalf of students, educators, and communities across the country, I implore the leaders of our nation to continue support of telecommunications technology: a decision vital to our children's future.

Sincerely, Bill Burrall.

Senator ROCKEFELLER. Mr. Burrall, am I not correct in saying that in 1994, for the first time in our history, that personal computers sold for home use outsold television sets?

Mr. BURRALL. Exactly. I read that recently. Yes, that is true.

Senator ROCKEFELLER. And that Internet, which now covers 30 million folks, is going up 10 percent every month.

Mr. BURRALL. I read some stats on Prodigy alone. They now have a fully functional web browser. It is slow at 9600 baud rate, but they are putting on 10,000 new users per day—10,000 per day. It is phenomenal the growth that is there.

It is incredible. It is hard to fathom. And where it is going, nobody knows. Nobody knows when the big crash is coming. [Laughter.]

Mr. BURRALL. Well, we saw a little crash this morning. [Laughter.]

Senator BURNS. Are we going to have another big bang in cyberspace? [Laughter.]

Mr. BURRALL. One of the problems I do see down the road is as this technology evolves there is a definite need for standardization not only of equipment and software but standardization of connectivity, the types of lines that are going in, to make sure these things are available to all users. And it is even more critical in rural States such as West Virginia, and I know we have a lot of other rural areas in our country.

OK, with that I will mention one more thing. Part of the project that we are doing on another smaller network that we are presently involved in, involved a letter here that was sent to us 2 days ago from Governor Keating from Oklahoma, thanking the students for sending concerns about the bombing in Oklahoma. This came in through the wire, through our modem, through our slower dialup connection.

OK, with that I would like to go over and show you a few things on the net. I did come prepared with a backup of some hard copy printouts, so I will share those with you. [Pause.]

Again, we will cross our fingers on this. I would like to thank Tim Kyger especially for having these bookmarks up and running. I E-mailed Tim my 2–1/2 page statement, which you should have, and I also E-mailed Tim a list of about 12 sites to put in here just to save time. So we will go to a few of those sites right now, just to show you some of the things we are doing in the classroom.

He has created a personal pages list for me, and I want to show you one in particular here to start off. This is called Web Crawler searching. It will take a few seconds to access this server. When it comes up you will see a search page. Now, we call this a search engine on the Internet. And when this engine comes up you will see a little field here, I click in it, and I can type in any word whatsoever. This is used every single period of the day that I teach my kids who are doing reports across the curriculum for science, social studies, English, it does not matter. So we can go in here and find any topic you want.

Now, we have this set. Down here at the bottom you will see it is set to do 25 hits, we call it. We can up that to 100 or 500. 25 is usually more than sufficient. What it is going to do, it is going to search the World Wide Web for 25 computer servers that have a key word that I am going to give it.

Mr. Toole mentioned telemedicine. If I want to know anything about telemedicine I simply do a search, and immediately it connects and pulls up 25 sites. Now, from here I can go into a telemedicine home page, health and medical information, pretty much anything I want about telemedicine is here. Here is data bases. Let us go to their home page and see what they have here for us, and notice the blue text you are seeing on the screen is called hypertext.

We do not have to type in a path, as you would in a UNIX operating system environment. It simply finds that path immediately—there is Calvin and Hobbes, kind of cute—and connects us to literally anywhere we want to go: telemedicine defined, reasons for telemedicine—you want to know some rationales on why connectivity is important for rural hospitals, this is where you will find it, right here. And we will not belabor the point staying in there, but you get the jist that you can connect and find information pretty much anywhere you want.

We can go back one page at a time, quickly go back to the site here, and I will entertain a suggestion from the senators on anything you would like to look up. Pick a word, pick a subject.

The CHAIRMAN. OK, the Black Hills of South Dakota.

Mr. BURRALL. Here we are, State of South Dakota. You notice it gives me 25 hits again: State indexes, State of South Dakota, and I know that South Dakota has a home page so we will just click on it. And from here we can go into tourism information, and this connection is fairly fast, as I said, and it is finding a server in South Dakota.

Now, you will notice up here we have what we call HTTP path. HTTP refers to hypertext transfer protocol.

This is the actual technical part of it that transfers this page, and you will see we get full graphics, we get color, we get text, anything in blue we can cross-reference and connect to that server, and this comes from South Dakota: events, cities, more information, accommodations, maps.

The CHAIRMAN. It might not have the Black Hills per se.

Mr. BURRALL. It is there somewhere, I guarantee you.

The CHAIRMAN. National State parks.

Mr. BURRALL. Yes, it is probably there somewhere, and it is just a matter of keep searching until we find it.

Right away, I think you can see the ramifications in the classroom. You have all heard the term "edutainment," where software now is being written to entertain the kids and fool them into learning, and I like to refer to that as stealth learning. But this is what we are up against now, and it is a tremendous tool for the kids to use.

OK, I am going to go to some other sites here. One of the projects we are presently doing at Moundsville Junior High is called our voices of youth project. We are tying in two networks. We are tying in our learning network with this, and this was the world summit for social development which was held in Copenhagen, Denmark. We found this site and decided we would participate. I had over 100 students send essays to world leaders in Denmark. The world leaders sat there in Denmark and read their messages on the screen. And I will show you some of those right now.

One of the schools that we are connected to, on our smaller network, is Northley Middle School, I believe, in Aston, Pennsylvania. They do not have full Internet access. They do have a modem. So we just said how about sending us your comments, we will forward it to Denmark for you, and this is what we can do.

Here we have messages from youth indexed by country, and you will see how many countries were involved here very quickly. I believe there were 81 countries represented. So we can read student messages to the world leaders from any of these countries. Our interest is here in the United States.

Let us pull up the United States, input from students, and here you see Northley Middle School, Aston, Pennsylvania.

This is a message they sent to us at Moundsville Junior High through modem. They do not have this high-speed access. We simply had our students forward it to Copenhagen for them, and this is the actual, as it comes in here, this is the actual essay here that was sent from Northley talking about the problems of population.

This world summit, by the way, focused on problems which are global—population, human rights, things like that—so the students had a good time and a lot of creativity involved here. And as we already mentioned—Senator Burns mentioned that students, when they are writing for a global audience really pay attention to what they are writing, so it is enhancing student skills, no doubt, in that area.

Let us go back a page, and I will not take too much time to pull individual essays, but I just want to show you that we are just in the A's, this is alphabetized by first letter of first name, and you can see from all over the country that we have students all ages—12, here is age 20, age 14, so college students as well, higher education.

Here is Oak Glen Middle School, which is right up the road from us in Hancock County, and you will see as we come down through here, and if I went through the entire list, here are two students here: Alicia Crow, 15; Alicia Menendez. I told them I would be pulling this up on the screen and they got all red-faced, so we will not get into reading their essays. But there are two from Moundsville Junior High. As I go down through this list A to Z, and we will not take the time, there would be over 100 students from Moundsville Junior High here.

The nice thing about this is you can go into this and you can also get the messages from world leaders. So world leaders, and there is a list of them, and I am sure some of those names are familiar to you, they responded with essays back to the children. So my kids can now pull up their messages and see what important statements they had to make for the students.

OK, let us go to another one here. I think everyone can identify with this one. This is a site I use frequently, and a lot of my teachers do that I work with. What is critical in education, you know, we do not get a lot of the funding that is out there in the corporate world. So consequently, we have to write our own grants. And I presently have over $125,000 worth of grants pending, crossing my fingers on. Where do you find grant information? I am trying to access the U.S. Department of Education home page which is a little bit slow in connecting here, and let us just stop that. I think I have it bookmarked as another one: grant opportunities in information. We will go to another server that we can connect to, hopefully.

One thing you do have to realize with technology, and I think you have experienced it from terminals probably within your chambers that—sorry, cannot see this file at this time. OK, and let us go back to the other one. We will try that again, Department of Education. There is no guarantee that you are not going to encounter some type of a glitch periodically, which this, was a connection problem. We are not going to get that one either.

Senator BURNS. The Wright brothers did not get off the ground the first time, either.

Mr. BURRALL. That is exactly right.

OK, here a is special report, the Oklahoma City bombing.

My students were glued to the monitors in my classroom. I have three of these machines up and running in my room, I have four students on those machines, that is 12 at a time every single minute of the day. When this bombing occurred it devastated the country, of course, and we found this site out there, and we were getting updates before they hit the newspapers and the news media. And you can see as this thing evolved—we can pull up this one. I think I printed this one out, by the way, but this page came in in full color, and students really followed this closely.

Senator ROCKEFELLER. Why were you getting the updates before the news media?

Mr. BURRALL. Somebody is probably right on the scene, I would imagine, who has control of this particular server, and they are feeding information to that (server).

Senator ROCKEFELLER. And the people who are doing it are doing it for whom?

Mr. BURRALL. Well, wherever this server is located, and this is Nando. This might be coming from the Nando times, so this might be a news release, but there are sites out there who send individuals there to get first-hand information, and they get back to their computer system and they can become a host site on the web.

Senator ROCKEFELLER. So in a sense, an individual could go out there to serve all across?

Mr. BURRALL. Exactly. Let me show a quick example after we leave this one. That is an excellent point. You see here we can pull up photos from Wednesday, we can go back to the day of the bomb-

ing here and pull up photos from that scene. I think you saw the quality of the printouts that I had on that printer. That printer, by the way, is under $500, excellent quality.

So here are some pictures that came the day of the bombing, and it will take a little bit longer to load in the graphics. They have several files here, but I will just let it go and see if we pull those in. Here they come.

You will notice the bottom of the screen there, document received. The numbers you see down there reflect the amount of information in bytes, OK, one byte being equivalent to the character on the keyboard, and graphic pictures take up a lot of memory, so it does take a longer time to load those.

You also notice that my pointer is an arrow. As I move into one of the blue-bordered areas it changes to a pointing hand.

This means that this picture is actually a hyperlink, as well, so I can click on any one of those pictures, such as this one, it will go out, find that server again, and pull the individual picture back in larger size for me, and this is normally how we print the bigger ones out. This one happens to be 23,000 bytes in size, fairly large, and it keeps you abreast of the status at the bottom of the screen. We have already downloaded half of it, and are waiting for the other half.

The T–1 connection functions, and Mr. Toole, correct me if I am wrong, I think it is about eight times faster than this. Is that right, ball park figure? And so it flies. And we do have connections like that courtesy of Bell Atlantic in our State.

OK, so you see the large picture there and caption underneath.

Senator Rockefeller mentioned people can serve as individual sites on the web. I am going to take you to a site in West Virginia right now which is called Brooke High School home page. Now, what you are going to see come up on the screen here in a second is coming from my good friend John Fluharty's home, This is where his server for the school is located. It sits in his home. He leaves it turned on 24 hours a day. Anybody in the world can get into this site.

My school has one under development of the home page right now where you can actually pull up a picture of our school building, information about our school, it is very time-intensive to build these home pages, but you can see, here is Brooke High School home page, and information can be hyperlinked to look at Brooke High School, and there is one right there.

Information about the Senate or Congress can be taken from a site called Cap Web, a guide to the U.S. Congress, and some of the pictures, Senator Rockefeller, I have in your folder came from this site. And we can get in here and look at pretty much anything about the Senate, we can go in and look—I pulled up pictures of Senator Burns, Senator Pressler, just to get a look at you guys before I came here, but your pictures are right in there, accessible fully to anybody in the world.

While we are waiting for some of these images to come in, do you have any questions?

Senator BURNS. I am just amazed on what you can do with it, and I will tell you when we were talking about multimedia in a classroom, I brought in a young teacher from Cold Springs School

out of Missoula, Montana, and he was into multimedia using cable and this service in his fourth grade class. By the way, he has gone on now and he now works for TCI in mixing these for other schools; in other words, the technical. And Steve, I do not know whether you knew John Klugman or not, that was up there in Cold Springs School just outside of Missoula.

Dr. RUNNING. Yes, I read in the paper when he took the other job.

Senator BURNS. He is doing well, by the way. But it is more and more teachers. I want to ask, Bill, how are we doing in our colleges in universities in teaching our teachers to use this technology? Because we understand that we are limited only by if the teacher understands it and knows how to use it.

Mr. BURRALL. Exactly. There are programs under development. It has been an area which we have lagged in, and I know that is a statement which could be attributed nationally. But programs are under development now. At West Virginia University they just received a $3 million grant which will be called Rural Net, and I am very proud to be working with them this summer as one of their lead trainers in training teachers at the higher education level, prospective teachers who will have these skills when they go out on a classroom.

It has been an area which has been weak. As I said, it is evolving. We are evolving with this technology. A lot of people ask me how did you get to that point with your skills, and I feel I do not have an answer because I am not at any static point. My comment to them is I have to run full speed just to stay behind. It is evolving that fast.

Senator ROCKEFELLER. Can I just ask an irreverent question about the value of all this? There are two senators on what we call the minority side of things in this body who cannot even do E-mail within their own offices—E-mail—forget Internet, E-mail. And some of us are trying to work to get senators online. Their staffs are tremendously skillful and able and World Wide Web is picking up, virtually almost every day. We actually have what we call a Net squad which goes around and puts pressure, advisory pressure, help pressure, to get Senate offices to increase their capacity.

But there has been, in some of the recent literature, a second guessing about this, and I just want to give you a chance to shoot this down, if it can be, and that is that this becomes such an end in and of itself that students, young people particularly, become sophisticated but in the end they do not end up learning.

Now, I am talking perhaps more from home than the classroom because you are in charge of the classroom, but my 15-year-old can spend 4 or 5 consecutive hours on any given weekend just working this thing, and he is brilliant at it. I sometimes walk in and I wonder what is it that he is learning from this other than the mastery of technology, a sense of the fact that there are things out there he does not understand, and yet he can get to them. Do you see what I mean?

Mr. BURRALL. Exactly. I would answer that in that it has to come top down, higher education. We have to train the teachers who are now coming on to the market, the educational market, to not only teach this technology, that we have taken on—those of us who are

using it presently have taken on this role already. We have to teach responsibility. This is the problem, and as Tim was setting this up he said he was only here an hour. I said come on, I know you probably stayed 2, 3, 4 hours, because I know he has not used this much.

You have to be conscious of the fact not to become so enamored with the technology itself that you lose focus on what it is for. So as educators, our primary role is to teach. We had the Web Crawler, tremendous search engine. It will find anything you want. Now, I know if I turn my kids lose I know what they are going to type in to search for.

They pull up MTV and they pull up some other things, but I say that is not the point. The point is use it to its best advantage. It is a responsibility factor.

And as far as at home, we have no control of that. Also, the education has to come to the parents to oversee their students' learning, as well. But I think if we teach the responsibility then a student has the opportunity to take control of his own learning, and many of my students have.

Now, you will have those few, and you will have a percentage who still want to go out and find the MTV's and the sites that they really do not need to be into educationally, but it does exist, and I think if we approach it from teaching responsibility, as well, that we can certainly overcome that.

It is a challenge. This whole technology thing is a challenge.

One last thing, because I know these gentlemen have some sites to see, this is a connection we have here, this is from Wentworth, and I think I enclosed in one of the folders I gave you a copy of one of the publications called Classroom Connect. This is an excellent resource guide for teachers, and it is the best I have seen on the market. And they even have their home page up here. And you will see down at the bottom of this one, if I have a desire to go in and look about anything for lesson plans I just simply point to that site, I click, and I can go out and glean a wealth of information about K–12 classroom communication projects. I can go in and do dictionary searches, thesauruses, here is an acronym dictionary, periodic table of elements, it is all here.

I will caution you that any of these pages that you get into that have the blue hypertext links you could literally spend the rest of your life in front of the monitor and not get up and barely scratch the surface on this, it is that vast. All the wealth of information in the world, the knowledge base let us say, I think the latest figure I heard is that presently it doubles every 2 days. They estimate that in the year 2000 all the knowledge in the world is going to double every 72 minutes.

Senator BURNS. Not with me, it is not. [Laughter.]

Senator BURNS. Well, Bill, we appreciate this very much.

And we have been joined by Senator Stevens now, who takes into a great deal of interest as far as resource management in his great State of Alaska, and I want to ask Dr. Steve Running now to give us some kind of an idea on the work.

STATEMENT OF SENATOR STEVENS

Senator STEVENS. I have a question, just one question.

Why is there not some way to put some earmarking of relevancy per age group or class group? We have trouble with overwhelming people in rural areas that try to get into it and start using it as a management tool for education. The teachers just do not have the capability of reaching in and categorizing things that are good for second grade, third grade, fourth, or so on. How could that be done?

Mr. BURRALL. The site that I just took you to from Wentworth, and there are others out there, an excellent site which ironically is one we were going head to head competition with for the Smithsonian Computer World award in our prison project, and we lost out to a site called Ask Eric. This is the site that won. Ask Eric does categorize and has high school-based information, middle school-based information, K–12 information, so it is out there.

The problem with the Internet, as it evolves right now, and I think it is coming, there are no finite structures to it. The wealth of information is there, but the categorization of it is terrible right now, and it needs to be structured a little bit better where people can find things.

But again, it comes down to the comment I made, the largest functioning anarchy in the world. Nobody is controlling it right now.

Senator STEVENS. I am not talking about controlling it,

I am talking about being able to utilize it. How can we assist people who do not have the time to do these categorizations? How can we help somehow or another get some ability for the teachers to know if you want to use this, this is your part of this world?

Mr. BURRALL. Exactly. My comment to that is the report that came out of the U.S. Department of Education called Prisoners of Time. As teachers, this is what we are faced with, that regulation of a 180 school day, 6 hours, read the book chapter one. There has to be some flexibility built in. There has to be time allotted with incentives for staff development.

Teachers have to have that staff development to feel competent in using these technologies. The way it is happening now, there are a select group of people—select is a bad word, but a small group of people who are saddled with all the responsibilities.

I said I had a phone line in my room. Sometimes it is a curse. It never stops ringing from teachers Statewide and what I do on a national level now. I get calls from everywhere. We did a project last year, 2 years ago, with Akutan School in Akutan, Alaska. They were involved in a telecommunications project with us. Now, to show you the importance of how this technology is important to them, they are on an island, Akutan, on the Aleutian chain, that has a total town population of 95 people. Their school consists of K–12, 25 students.

Now, their project they sponsored that we interacted with them was guns, gangs, and graffiti. Now, you might think, why did they choose that as a project? Surely you need guns for protection. Gangs? I bet you I know who is in them—town population 95. And graffiti, you could probably identify the handwriting. That is not the point. The point is they wanted to glean the information from the outside world on what problems you are having with guns, gangs, and graffiti.

But in respect to your question, there is a responsibility factor of the administration to free up the teachers with time. It is a very important point, and a very necessary concern to train teacher staff development-wise with incentives. We just cannot say you are going to attend 6 hours of training on your own time. It is not going to work.

It is not working.

Senator BURNS. Dr. Gowen, do you want to respond to that also?

Dr. GOWEN. Senator, in a moment. I would like to show you what we call the High Priority Connection, because it is exactly what you are referring to.

Senator STEVENS. Well, I would like to see it, because I have a daughter who is an instructor in K through 8 in schools in Alaska, and one of the great problems about management of the tremendous amount of information is how do you pass on to the student how he can commence using it. You know, kindergarten—we are not going to get into this, but by the time they get to about the fourth or fifth grade, sixth grade, they are into it, but they are lost in the world. And I think that is the trouble with the World Wide Web, that we ought to have a few cities and counties on it that people can get use to it before they get out into the world.

Senator BURNS. OK. Dr. Steve Running, from the University of Montana School of Forestry, one of the outstanding forestry schools there is in the country.

Thank you, Bill, and we appreciate that, and we will probably have some more questions for you, and thank you for coming.

Mr. BURRALL. Thank you.

STATEMENT OF STEVEN RUNNING, SCHOOL OF FORESTRY, UNIVERSITY OF MONTANA, MISSOULA, MONTANA

Dr. RUNNING. I will be showing a number of images, so I am going to start the first one right away, since these take a while to bring up. And as the first one loads, I will then start explaining a little more about it. With the faster lines, these load in my office in 1 or 2 seconds, and so we are paying the price for a slower connect time here.

Senator BURNS. It is the Government, you know. You have got to remember that. They were wondering the other day if the Senate was going to move as fast as the House, and I said we are moving at blinding speed now compared to when I first came here. [Laughter.]

Dr. RUNNING. Would you not know it, when you have an audience all watching you have a blank screen.

Now, what I am going to show you is that I think after this first introduction to Netscape on education, what I want to now show you is some of the capabilities that are ready for natural resource management. Because I think we are in the similar situation where we are posed at the edge of being able to take natural resource management to a much higher level of sophistication if we have a better network. This is a great example of what we need to solve, just basic connectivity, because the knowledge and the technology behind this is established now.

Senator STEVENS. You have to explain to me why this delay is taking place. You have got your location.

Dr. RUNNING. I am trying to draw or bring up from here another set of images.

Mr. BURRALL. If I could interject something about the connectivity and the access we are experiencing here, this connection, a good analogy would be a large garden hose, and we are talking about bandwidth here. The more people who are on that, using graphical applications, full motion video, things like that, they are eating up most of that bandwidth.

They are competing for speed, in other words. So if we had the faster connection that has the bigger pipeline, we would not experience this. But the smaller the connections link and the more people who are using that water supply through the hose, it does slow down.

Dr. RUNNING. We, in fact, have found that there are certain times of day that we do not bother trying to do certain transmissions across country, and certainly internationally, because the response time just slows way down.

If you sit in Europe and try to do your E-mail you avoid the main part of the work day on the East Coast here.

Boy, this was doing much better 2 hours ago.

Senator STEVENS. There is no way to go around that?

Dr. RUNNING. No. I will not show you as many images as planned. I had eight planned, and I will take that down to more like—and here we go—what I will show you is an example of drought monitoring. Now, we have finally got this first one. I think in the West we can certainly relate to drought. We can now, by combining satellite data, climate data, and computer model, we can map drought on a weekly basis. And so this is an example. I am going to bring that up more slowly.

You can see the upper image of a time in late May to early June, and this was from 1990. And then the satellite image pans down to the middle of July, and so what the satellite and our computer model has done is a continental mapping of the progression of the summer drought starting in mid-May, and now July. We can do this every week, and so we could map the drought conditions every week basically forever from this type of system.

Now, this is not in place for management yet, though. It is only a research tool, and until we can get better connection and get the networks out to land managers and land owners they are not going to have this available, even though the basic technology exists to do so.

That is one of the examples, the drought monitor. Let me take you to another that as Westerners we can relate to, wildfire. For a number of decades the Forest Service has had what they call the National Fire Danger Rating System, and this is all done from ground weather station data, and you may have seen the little fuel sticks at the district ranger stations. We can do a satellite derived mapping of ignition potential, what it really is, the danger of wildfire ignition, we can now do by satellite. And let us hope I have got an image of Oklahoma here. Our fire lab at Missoula has done this.

This is the burning index for Oklahoma for a day in August. And this, again, could be done every week. We could have an ignition index produced every week for the whole Western United States,

and this could be at the fingertips of every Forest Service or Bureau of Land Management or every land manager could have the weekly burning index come right to their office.

Certainly, if you have questions on any of these as I go through, since they are slow, I am going to move right along.

The next one I want to show is snow cover. And again, our snow pack is so important in the West. It is our source of irrigation. Of course, down river they worry about flood control. It is also our hydroelectric power comes from it, fish runs on the Columbia, I do not need to over-emphasize the importance of the snow pack.

Well, we can monitor that snow pack, again every week, with a combination of these satellite and computer models.

And so what I have here is—and on some screens this will show all at once, and I do not know why this screen will not scale correctly. This is, if you can see—I hope you can see that this is Washington, the top of Idaho there. I am afraid from your distance you cannot see.

Senator BURNS. We can see it fine.

Dr. RUNNING. The snow depth for February 19th, and the other image here—let me bring this across—the other image is the same period on May 1st. And so obviously the snow has melted. And the point is we could, week by week, monitor this snow pack melt by satellite completely across the West, certainly across Alaska. We could do this all with this satellite and computer model and deliver this information every week to the desk of the land managers, and this is a capability that you can see exists, but it does not get to the land managers yet because the overall network does not exist to get the information to them.

OK, let us go down. I am going to back up—those raw images from projects of our NASA Earth Observing System, and I am going to back up—oh, I backed too far—and go to the next type. I have a wildfire severity image that I am going to skip, and go to a water quality image of Flathead Lake.

And this is another example of the type of resource management information that we could have every week in the hands of information managers.

In this case, we are mapping the chlorophyll concentration in the lake. It starts with a satellite image.

And then, with computer model enhancement—and this could be done every week, following the water quality of the lake.

And as before, these are big images. You can see the top of the lake. And I am sure Senator Burns has been to Flathead Lake a lot of times. The Kalispell and Columbia Falls treatment plant comes in at the top. So there is nutrient loading there. And so you do get a burst of chlorophyll at the top of the lake.

As you get to the middle part of the lake here, it is very deep and clear. And when I am out on a boat, I just drink water straight out of the lake, it is so clear. And that shows by a very low chlorophyll density. And then, as you reach the lower end of the lake and Polson Bay, you get higher chlorophyll again.

Again, for any water body, you could have a weekly water quality mapping of a water body, a large river or a coastal zone.

The next thing I want to show you is one example of wildlife habitat that I have here. I have dozens of images on my home

page, but we are not going to see them all. When the Senate is connected, you will be able to bring these up any time you want yourself.

I am sure you have lots of spare time to do that. And at this baud rate, you had better have.

Senator STEVENS. Well, the problem is we have got senators who want to put up pages themselves and make them available to you.

Dr. RUNNING. This certainly is an active, two-way street in that regard. Everybody from the smallest, little town to the big research centers has access to the same information.

And I think that is really important in rural States like ours.

I will just show you the mountain goat habitat of the Seeley Swan Valley, and I will not show you the vegetation map which I had planned. But this is combining the topography, the vegetation, the microclimate of the mountain ranges, the habitat preference of the mountain goats. And this is all put together into a final mapping of the mountain goat habitat.

Senator STEVENS. You put this together?

Dr. RUNNING. This was done with one of our teams at the University of Montana.

So here is the Seeley Swan Valley. And the predicted habitat is along the Mission Mountain Wilderness Area here.

And of course, the edge of the Bob Marshall—at the higher elevations of the Bob Marshall Wilderness.

OK, the final—and I think I have taken my share of time—the final image I will show you—and, in a way, is one of my favorite projects—is the Montana Forest Productivity Project, which we just finished. And also integrating satellite data, climate data, ecosystem models, and what we have done is I think the first comprehensive mapping of forest productivity of the whole State.

Senator BURNS. Any surprises?

Dr. RUNNING. I think the surprises are probably that the productivity is not as high as we wish it was.

But here, with this project, we have mapped the forest productivity. And we can look at this on various scales.

Now, obviously, probably only the Governor worries about the productivity of the whole State, and most land managers would really only be worried about their little township. So we can go down now.

This is actually below Missoula, along the Clark Fork River. And as you well know, Senator Burns, the lower hill slopes are dry grass, sagebrush. And as you get higher up, you get into the forest. And that clearly shows on the map here. And this again is something every land manager could have at their fingertips and at the desktop.

We have the technology with the satellites. We have the computer power and the weather station data. But what we do not yet have is the final network capacity to deliver these sort of products that we are building in the university out to the land managers and landowners.

I think, with that, that is the last one.

[The prepared statement of Dr. Running follows:]

PREPARED STATEMENT BY DR. STEVEN W. RUNNING

A tremendous synergism is evolving amongst the technologies of satellite remote sensing, computing and telecommunications for Earth sciences and natural resource management. When the first Earth Resources Technology Satellites were launched in 1972, the optical accuracy of the satellites was poor and uncalibrated, and the computer power to process the stream of digital imagery transmitted to Earth was primitive compared to todays capabilities. As the suite of Earth Observing System satellites are launched beginning in 1998, part of the NASA Mission to Planet Earth, an unprecedented array of satellite based information will become available. EOS will produce satellite data covering the globe at variable space and time detail with a consistency not now possible. Of equal importance will be the high precision of new EOS data resulting from sophisticated in-flight calibration of the sensors. The enhanced precision of EOS satellites will allow accurately measured land products, prototypes of which I will show today.

Fortunately, as satellite technology is evolving, computer technology is doing likewise, so the personal laptop computer I carry today is probably 1000 times more powerful than the university mainframe computer we used as graduate students at Oregon State University in 1972. The 1000GB/day processing planned by the EOS Data Information System would have been absolutely impossible 10 years ago.

The final step in exploiting the vast information that will be collected by EOS is the distribution of that processed data to users. Distribution of these data to the global-scale research community will be fairly straightforward, as those scientists work at major universities or government research centers which will be linked by state-of-the-art network connections. I will show two examples of these global terrestrial science products that will be available from the EOS computer network. First will be a map of vegetation productivity useful for estimating forest, range and crop productivity worldwide. The second image will be a map of global landcover change from human activities. Both of these satellite based products are important in representing the land surface in global climate models.

However, the utility of EOS and other advanced remote sensing products by the larger scientific and resource management community will hinge on their ability to access a regional subset of these global data in a timely fashion. In my demonstration today, I want to concentrate on the remote sensing based products that should prove particularly valuable for future natural resource management IF managers and land owners can receive the data quickly and easily. I will show samples of research products that have been developed over the last five years in the western United States, and discuss how these need to be delivered for optimal utility.

The single biggest factor in making these advanced remote sensing products truly useful to managers and land owners is near-real time delivery at low cost, and this is where the "information superhighway" is the critical final component. The best current example of near-real time satellite data use is the nightly weather forecasts we all watch on television, distributed by the National Weather Service, derived in part using the NOAA Geostationary Operational Environmental Satellites (GOES) data. I envision a new era of land management that can have weekly satellite data distributed to users in much the same way over the "information superhighway".

Some of these products are generated by incorporating topography, soils, daily weather information, and landcover maps integrated with advanced computer simulation models of biophysical and ecological processes. The final products give much more realistic and quantitative mapping of land surface activity than satellite data alone can provide. Here are some examples:

(1) Drought monitoring: This image shows the change in a Drought Index that was calculated from Spring to the Summer of 1990. Both visible light and temperature data from the NOAA AVHRR meteorological satellite are used for this index. This Drought Index could be computed and distributed weekly, but is currently only a research product developed at the University of Montana. Decisions on grazing concentration or irrigation timing are possible uses.

(2) Burning Index: This is a fire danger index map of Oklahoma that incorporates topography, ground fuels, daily weather data and satellite data into a mid-afternoon measure of the risk of wildfire ignition. This is a propotype for the next generation National Fire Danger Rating System of the US Forest Service, developed at the Intermountain Fire Sciences Lab in Missoula, and could be distributed daily. Mobilization of fire crews depends on these forecasts.

(3) Snow Cover: Accurate monitoring of spring snowmelt is essential in the Western United States for predicting flood events, summer irrigation supplies, and dam operations for hydroelectric power. This image from the NWS National Operational Hydrologic Remote Sensing Center in Minneapolis used NOAA AVHRR data to map

the snow cover change from February 19 to May 1, 1990. These snowcover maps could be distributed bi-weekly via computer network.

(4) Water quality: This image, from the University of Montana, shows water quality of Flathead Lake, in western Montana, on July 16, 1984 as measured by chlorophyll concentration. Satellite based water quality monitoring of freshwater and oceans will be done weekly with the new EOS sensors.

(5) Wildlife habitat: This image shows the vegetation cover of the Seeley-Swan, a mountain valley in western Montana, and the mountain goat habitat of that area. Topographic and habitat preference factors are merged with satellite data into this analysis of wildlife habitat, done at the University of Montana as part of the U.S. Dept. of Interior, Fish and Wildlife Service GAP analysis program.

(6) Forest/Range/Crop productivity: The seasonal production rate of crop, range and forest land can be followed by integrating NOAA AVHRR satellite Greenness Index data with daily surface weather data. This image is an example, sponsored by the State and done at the University of Montana, of a system to calculate the productivity of forested land using satellite data. Decisions on range cattle allotments or forest harvesting are examples of land management that could benefit from these data. These Production Indices could be computed and distributed weekly nationwide.

Of course there are many other interesting projects using satellite imagery in innovative ways elsewhere in the world, such as mapping malaria outbreak potential or grasshopper population dynamics in Africa. These examples highlight activities I am involved with in the western United States only. All of the above products have been developed and tested by various research groups and agencies in the last five years. All of them could be used by landowners and managers if they could get access to the datasets quickly with low cost computers and network connections. In each case the primary remaining hurdle is to provide the networking that can allow this information transfer, particularly to rural agency offices and landowners.

The Earth Observing System program is concentrating on a Data Information System to transmit processed satellite data to users. The EOS Data Information System is a cooperative activity of NASA, the Dept. of Commerce (NOAA), the National Science Foundation, the Dept. of Defense, the Dept. of Interior (USGS), and the Dept. of Energy. However, the computer network facilities to reach beyond the science community to land managers in rural parts of the United States, require more than EOS program responsibility alone. Advances in land management in the western United States will rely on high speed telecommunications to use the types of new information shown today. I encourage the continued development of the "information superhighway".

Senator BURNS. Dr. Gowen.

STATEMENT OF RICHARD GOWEN, PH.D., PRESIDENT, SOUTH DAKOTA SCHOOL OF MINES AND TECHNOLOGY, RAPID CITY

Dr. GOWEN: A few moments ago, as you were observing the demonstration going through Internet, I believe, sir, you mentioned that sometimes you need to be able to turn to the kind of people who use the Network all the time. With me today is a gentleman who graduated from our institution a year ago, and he is part of our productivity team.

I am so pleased he was with us today, because Steve Bauer helped to get Internet back on-line for this Hearing.

I am here to show you a system designed for those who are not computer experts, but need to use computers.

Our goal in the South Dakota School of Mines and Technology is to bring this type of a product into the hands of the developing companies in rural America. Our experience has shown that we need to take the vast amount of information available in the World Wide Wel—categorized to me as being the largest library imaginable without a card catalog—and make it useful to business. Frankly, those in business do not have time to search through the Web.

Browsers are exciting, and they will search for a specific item. But, so oftentimes in business or in education or in government, we need an answer right away without completing a browser search.

The system we have developed is called the High Priority Connection. This system is located in South Dakota at the South Dakota School of Mines and Technology. The purpose of this system is to serve business and industry.

Our experience has been in providing assistance to industries. We have worked with a number of companies in South Dakota and the High Priority Connection has evolved from these experiences helping business and industry. The High Priority Connection is oriented to help rural America. Our goal is to develop an electronic network that links users with needs with providers with services through the Internet.

A major concern is bridging the distances of rural America. It is difficult to go from town to town to find assistance for business and industry. In the days of several years ago, in the thirties in South Dakota, Wall Drug became very famous because Highway 30 went through South Dakota. When you came to Wall Drug you could get ice water which meant an awful lot on those dusty roads and the warm days in South Dakota.

Today the Internet serves as the highways for business and industry. Our High Priority Connection serves as the equivalent of the trucks of old to deliver the services over the Internet.

The High Priority Connection evolved from our Technical Assistance Program. This program makes available the resources of our university to serve the special needs of industry. The resources of the university are faculty, students and facilities. There is nothing like Steve Bauer to meet the needs of industry just as he met the needs of this Committee to reconnect to the Internet this morning. We work with our TAP projects to meet a specific technical need by developing a team that works in a partnership with industry.

These partnership teams that we developed are important in creating a product, to deliver services, and, for many of us in rural America, perhaps the most important goal of all, create new jobs.

Partnerships have ranged from developing diamond-tip knives for eye surgery to platforms for cleaning spray-planes. While working with these partnerships, we had to find new ways to bridge distances while still doing business.

One of the major issues challenging the Internet is to find the information that really counts—information that will help business succeed in developing products and services.

So the principal goal of the High Priority Connection is to make a very user-friendly interface. One of our objectives is to have the CEO or president of a company—or in the case of a university, the president of the university—be able to run the system.

On our campus, the objective is to make the system president proof. That is, if I can run it without crashing it, then it is ready for release to the public.

Our objective is to build a service system that does not require you to go to school or even to read the manual. It is our experience that most of us do not read manuals anyhow. The goal is to produce an intuitive network that is very simple to use.

User-friendly, then, has a very special meaning to make our searches simple. To accomplish these searches, we use the World Wide Web markup language combined with a very high-power database.

The use of the high-power database has permitted us to develop a very friendly intuitive system, and our ultimate goal is to use our system to create more jobs in rural America.

Senator STEVENS: If I am a small sports store in South Dakota and I have got two people there, me and one other person, how do I get some help from this and how do I even know it exists?

Dr. GOWEN: The way you know it exists is because we are going to contact you.

The buttons on the screen help you gain answers to your questions by accessing directories. This screen is a list of directories that will show the information that is available in the High Priority Connection.

The industrial sector uses standard industrial classification codes to identify services and commodities. We have used these classification codes to provide a user-friendly interface. You will notice after each code there is a number. These numbers identify how many of a particular type of company is listed under the code.

In industry, the standard classification codes are well understood, and would make it easy to identify a company in manufacturing. The number following manufacturing shows that in South Dakota there are 3,256 listings associated with manufacturing.

One of those listings that will come up on our next screen could be a company in electronics and other electronic equipment. These listings are nested. We begin with a short listing and have the opportunity to get to more specific information. The classification codes permit us to access approximately 18,000 different classifications down to more specific types of information to locate a company.

The High Priority Connection is a subscription service that permits you to obtain the level of support needed for industry.

Up until this point, everything I have been showing you is available on the World Wide Web and is free to anyone throughout the world. When you enter the subscription service, we in effect say, "We will take you into some very advanced capabilities of locating assistance for a fee for service."

Senator STEVENS: How often does this have to be updated?

Dr. GOWEN: We update it nightly as we add people to the database, or have added activities, or new providers, or new services. We have chosen to update nightly so that we use our system resources most effectively to serve our customers.

This screen is our marketplace—it is like a big bazaar anywhere in the world you might imagine in your mind. We begin with a choice between "white pages" or "yellow pages," that promotes the intuitive connotation that you are accessing a phone book with data using alphabetical or listing by company classification.

The yellow pages have examples of the many different kinds of services that will be available in our full operating system. Let's choose a South Dakota company, Sheldahl, which is a manufacturing company located in Aberdeen, South Dakota. It is a company that deals with electronics. It is a second-level supplier to General

Motors and Ford. Its continued growth and development is absolutely vital to our part of the country—the small towns. This screen shows a listing of information about Sheldahl.

If you were preparing a market search and wished to search the 15,048 listings in South Dakota, you could search electronic companies and identify Sheldahl and its capabilities.

Our hope would be, if you sat somewhere around the world, you might choose to use one of the features of Sheldahl and bring additional jobs to these folks in Aberdeen.

The screen I am showing you is a very simple way to shop through the information provided by companies and to learn more about the particular capabilities or personnel or services of a company.

Senator STEVENS: Do I pay to get on that?

Dr. GOWEN: You pay to put your advertising on the system. This advertising is then available to anyone in the world without additional charge. This provides an open marketplace for people to search capabilities. It permits us to be able to showcase companies in rural America that need to be connected to people who want to buy services or products. It provides a way to get these companies at a minimal cost.

Senator STEVENS: What does it cost the university to do this?

Dr. GOWEN: The State of South Dakota has supported the development of this system through the Governor's Office of Economic Development. There are no university funds in this development.

Senator STEVENS: What does it cost to do that?

Dr. GOWEN: The system costs $8.95 per month subscription. The development to get to this point has cost about $2 million.

Senator STEVENS: What does it cost you to load it?

Dr. GOWEN: We have built this system through a management and research development project. The cost of loading this system is minimal and is paid by subscribers.

Another example of how the Network can lead to a development of a particular service, is a company that started on our Indian reservations. A crop dusting company has a need to conform to the EPA requirements to clean spray-planes after spraying.

The particular developer of this company came to us with a concept of building a platform made out of steel. An alternative was to use concrete which is hard to use because it cracks and can lead ultimately to an environmental problem.

Our university provided technology that used advanced composite materials in eight sides to construct a platform with a deck of 40 feet in diameter. It gives a slope. It holds 940 gallons of fluid. This development helps to solve a very major problem in agriculture: the need to clean up our airplanes. It has created jobs in South Dakota and holds promise of additional jobs in rural America.

I would like to show you one other capability by using our own university home page.

This screen shows some of the sources of electronic commerce that is possible with our system and would let us buy items through our bookstore. Perhaps you could imagine this could be any store, even the retail store that you mentioned earlier, sir.

If you were to visit the bookstore electronically, you would have an opportunity to buy from this catalog. You can select items and place an order from the catalog, the price and information is included.

Our goal is to develop a system that ties into the Web in a way which small operations—your two-man operation, Senator—could be able to use the system and enter information they would want to put on our system.

We can provide manufacturing services that are needed in rural America.

We are moving to provide access to an electronic set of expert brokers. These expert brokers will tie into the many different government and other support levels available to provide assistance. We are identifying expert brokers, not just in South Dakota, but through interactions working with the National Science Foundation. We will expand our services into 19 EPSCoR States and use this help to identify the industry experts in those states.

The High Priority Connection will permit companies in 19 states to tie into the network and to help companies gain access to government services, particularly some of the activities at the National Institute of Standards, the NIST, NASA, and the TRP programs, and federal laboratory consortiums.

Those programs provide important access to government assistance. But, like the World Wide Web, it is hard to find out exactly what service is available through the programs. We provide high-level access for economic development, small business development activities, and the transfer of technologies.

You have seen demonstrations here this morning about the ability to bring in very large graphic images. This map shows the rural States and, much as you saw the demonstrations on education and the demonstrations associated with our natural resources, our goals are to assist rural America to connect to needed services.

In summation, this Network provides unique capabilities to tie people together. It helps people easily select services to ultimately build new products.

We strive to build the highest quality products at absolutely the most competitive price. Rural America can use the information highway to connect to the world and compete with the most current technologies.

In the future, we will connect companies to broker excess capacity in our machine shops to make better use of these capabilities, and to increase profit and ultimately more jobs.

[The prepared statement of Dr. Gowen follows:]

[PREPARED STATEMENT OF DR. RICHARD J. GOWEN]

Introduction: Mr. Chairman, Members of the Committee, I am Dr. Richard J. Gowen, President of the South Dakota School of Mines and Technology located in Rapid City, South Dakota. Thank you for the opportunity to tell you how we are using the nation's information highway to help the people of rural America compete in the global marketplace. We have developed the High Priority Connection Network (HPCNet) to link the businesses and industries across the heartland of America with the products and services needed to produce the highest quality products at competitive prices.

Network Overview: The High Priority Connection is an electronic network that uses the Internet to bridge the distances of rural America and deliver the information and assistance necessary to support the growth of jobs in our many small com-

panies. Much as the interstate highways of yesterday made it possible to efficiently link companies of hometown America, the Internet provides the electronic highway for today's commerce. The High Priority Connection Network is the electronic equivalent of yesterday's long haul tractor-trailer. Through the High Priority Connection Network we are able to deliver to the small companies of our rural towns services that are equivalent to those available to their global competitors.

History: The concept for the High Priority Connection Network evolved from the efforts of the South Dakota School of Mines and Technology, working closely with the South Dakota Governor's Office of Economic Development, to tap the resources of the university and create new jobs. During the past seven years, 66 technical assistance partnerships were formed to join the resources of industry, the state, and the university to resolve a specific technical need of a company. Our university made available the resources of faculty, students, and facilities. The Governor's Office of Economic Development joined with industry and our university to fund these partnership teams. These technical assistance partnerships helped to create products and services that range from diamond-tipped surgical knives to an advanced composite material platform used for cleaning crop spray planes, to high performance computer software.

As we worked with the industries of our region, we became aware of needs that were beyond our immediate resources. While there is a great richness of assistance available from companies, government agencies, federal laboratories, universities and economic development groups, a person in a small company often finds it difficult to find or judge the value of such assistance. Some suggested that we create the equivalent of the agricultural extension agent to help companies locate sources of assistance. However, the great distances between our manufacturing companies makes a system of such technology extension agents impractical. Instead, we chose to develop our electronic delivery capability using "smart" systems to connect companies with needed business and technical assistance. The resulting High Priority Connection Network combines the excellent presentation capabilities of the Internet's Mosaic software with the search and retrieval capabilities of a high performance relational database.

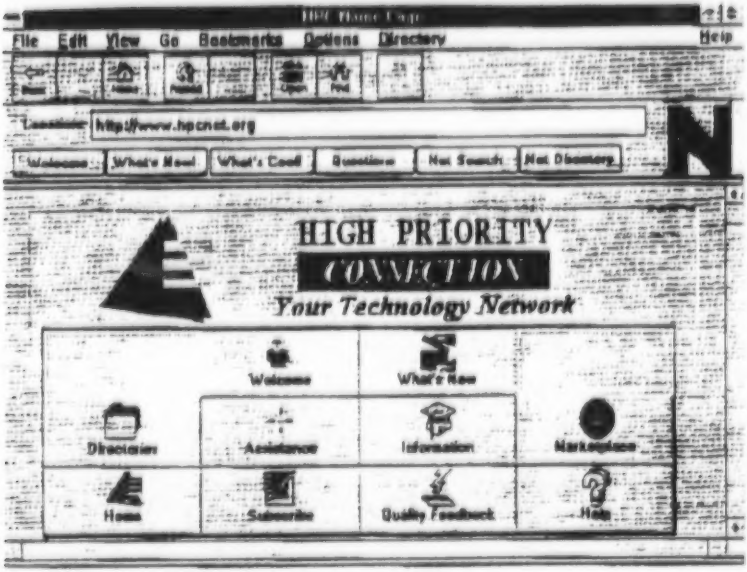
Technical Challenge: Our design requirements for the High Priority Connection Network placed special emphasis on the value of a "user friendly" approach to connecting companies with needed assistance. Early tests using the Internet and World Wide Web were described as trying to find information in the largest library imaginable without access to a catalog. We adopted the goal that the High Priority Connection Network should be designed to be so intuitive that even the CEO or President of the company, and in my case, President of the University, could successfully link to needed assistance without help or the need to read a user's manual.

HPCNet Structure: The High Priority Connection Network uses "electronic buttons," as shown below, to link to its four major features; directories, assistance, information, and marketplace.

The "directories" feature of the High Priority Connection Network provides the user with access to over 18,000 commodities and products through a menu of choices based on the Standard Industrial Classification (SIC) Codes. Through these menus users gain access to information about the products, services, key personnel, and unique capabilities of a company. The user will also have access to graphical and multi-media presentation of the products and services offered through the company. Additionally, the user is provided information to contact the company or the opportunity to send an electronic message requesting additional information or a follow-up contact. A significant aspect of the High Priority Connection Network is the identification of the number of items available in the database as classified with its corresponding SIC code.

Our database currently contains information on 15,048 companies in South Dakota. In cooperation with the National Science Foundation's Experimental Program to Stimulate Competitive Research (EPSCoR), we are preparing to include over one million additional companies from the 18 EPSCoR states and the Commonwealth of Puerto Rico. Most of these companies are small and many share the same need to bridge great distances to obtain assistance.

The "assistance" feature connects users with state and federal assistance programs, economic development services, and sources of technologies. Users of the High Priority Connection Network will have access to specialized assistance brokers to provide guidance in locating a solution to a business or technical need. A network of regional associates will help to identify the most qualified assistance brokers in the key areas of business and technology. An "expert" system will help users access leading edge technologies developed through public-sponsored programs like the successful NSF-State EPSCoR project, the National Institute of Standards and Tech-



HPC HOME PAGE/HIGH PRIORITY CONNECTION.

nology Manufacturing Extension Centers, and the Technology Reinvestment Program. Assistance services will range across the traditional business areas of finance, management and marketing to the operational and production needs in manufacturing and service industries, to the identification and procurement of materials and resources.

The "information" feature provides easy access to the information available through the Internet and World Wide Web. Dynamic menus will help the user access the most appropriate source of needed information. A broad range of state and federal business and technical information services available through the Internet may be reached through these menus. Additionally, the user may choose the assisted search services available through libraries and commercial information retrieval services.

The "marketplace" provides the companies of rural America with opportunities to place their products and services before the Internet users from around the world. The "value plus" feature provides low-cost access to electronic presentations that include pictures, audio, graphics, video and even three-dimensional images. Internet browsers need only select an electronic button to connect with one of our Network database-listed companies. The "exchange" feature will provide the Internet browsers with the capability to list or shop for technologies or services. "Exchanges" will support the growth of vital companies by using the power of the database to broker specialized commerce. One such company, Eco-Chem Network, Inc., developed by graduates of the South Dakota School of Mines and Technology, brokers the sale of large batches of specialized chemicals. Other exchanges will broker excess production capacity, the processing of waste, or special educational and training programs.

Status Today: The development of the High Priority Connection Network is a continuing process. Initial support for the development of the High Priority Connection Network was provided through the South Dakota Governor's Office of Economic Development with the intent that the operation of the Network ultimately become self-supporting. A major goal of the initial design was to build a network that would expand the opportunities for commerce in rural America through electronic linkages between people with needs and people who provide solutions.

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The basic design of the High Priority Connection Network is complete, and the Network is being extended to link users and providers in surrounding states. The National Science Foundation's EPSCoR program has funded the development of "smart" links for transferring the technologies developed by researchers to the companies within the EPSCoR states. Such development of links between users and providers will lead to the rapid expansion of the services available through the High Priority Connection Network and increase the value of this Network to companies in rural America. Shortly, the High Priority Connection Network will be available to the world through the Internet. Subscribers will bridge the vast distances of rural America when they access the advanced support services available on the High Priority Connection Network.

Senator STEVENS: I really think you have got a very good service; and this highlights the problem we face as to how to get into this system to make it relevant to particular users. That is a wonderful system. I wish our university had thought of it first. And I congratulate you for having Alaska on the map.

Dr. GOWEN: We are with you.

Senator STEVENS: I do not have any questions. I think that is very understandable. And it is a very worthwhile thing for the people of not only your State, I think the whole West will benefit from that.

Dr. GOWEN: Thank you.

Senator STEVENS: I appreciate that very much.

I did come in late, so I do not know whether some of you have not made presentations.

You have all made your presentations already.

Let me then go back and ask you all the same thing. I have with me my chief, working with me on the rules committee. We have the same problem in the Senate to deal with this and try to make it relevant to what we are doing. Do you use the Federal systems at all as far as your operations are concerned?

Dr. GOWEN: With great help and great support, and the ability to tap into the various Federal systems, including the testbed, is absolutely vital to all of us. And the Federal services that are available are truly impressive, and there are a number of capabilities there. The concern is, how do you know which is the right one to go to and how do you know which one will really help you?

So what we are evolving toward is a series of smart interfaces, a way that if you were using those services you could pull down a menu, and help you be able to move through, and know that this is the best service for you.

There is so much information available at times it is hard to know which is the best service one to use, and we have found that in rural America, that question is best answered by the people using the service. We plan to provide a quality feedback that users can index whether a service has been helpful.

Such feedback gives a way of knowing which of the Federal services will have quality payoff for those using them.

Senator STEVENS: Well, I tried to use this concept 8 or 10 years ago. We had the Small Business Administration try to assist small businesses in Alaska by putting a system through the university in Anchorage. It was a cooperative system with SBA and the university to help service the needs of small business.

The trouble was—and that is why I asked the question about the two-person operation—they told me that they just did not have time to make it relevant. It was not packaged for them. It was not

really down to the level of "this is for small business; this is for someone with less than 1 million; and this is for someone with 1.5 million gross; this is for someone with over 5."

They said that all of that stuff is great, but I am looking for something that specifically will help my business. My real problem with it is—and the same thing as a Senator—I am not interested in reading too much of what is going on in the other 49 States. I have got to try and make my operation relevant to my State if we are going to use the World Wide Web. I am not sure you got to the point of relevancy yet as far as the individual users, is what I am saying.

Dr. GOWEN: Senator, one of the problems we have found is that when we, in rural America, ask for help, we are often told that we need to follow the same type of approach used in large population areas, and the large manufacturing areas, or the large support areas. The way of approaching it is to provide an extension agent to visit and help companies.

You just cannot afford to have extension agents in rural America. The distances between small operations, our two-man or three-man operations, cannot be served by extension agents who travel in a car and must drive around between companies. We have learned to use Internet and electronic connections, and as we work with government agencies, we are finding increasing numbers who are beginning to understand that we can use the Internet to personalize services rather than follow the extension agent approach.

I am hopeful that we can find ways of working with more of the Federal agencies to provide a basic fairness that gives those of us in rural America a chance to compete, not just those in large cities.

Senator STEVENS: Yes, Mr. Toole.

Dr. TOOLE: Senator, I would like to comment on that particular question, because I think it is very, very important. I believe we are just starting to get into this new age of information. I think we are seeing the evidence of that. I think we should be excited with the fact that we have a certain frustration today, that we need the research and development to look forward to the future.

And that is exactly what I am excited about hearing these gentlemen see the real, grassroots implications of these type of things—your example of the small business I think is what is happening now. The marketplace is looking at these kinds of things. The research and development is starting to make a real impact. And as we look to the future of what we see the future to be - try to be and would like to be able to look at the kind of agenda, you see cooperative learning kind of strategies that would even fit on top of the things that you have seen demonstrated today.

The frustrations of trying to get on the Internet is only a symptom, but there are new protocols and things that have got to be looked at in the future.

So, in one sense, the frustration that we see—we are starting to get some insight into the nature of the problem. And that I think I see as I look at my children, as I look at schools, as I look at rural areas, as I look at high computing technology centers across the Nation, all of which are really driving toward the future. And if we can understand that and start to answer some of those questions, that is where we will make some progress in this particular area.

Dr. GOWEN: Senator, one concept—to add to that—and one of the reasons that I am very excited to be here today and urge that you do support the high computing concepts and the United States continue this activity—because what we are hopeful for is that we can ultimately figure out how to work on this linkage, and take those many small, computer numerical controlled machine shops that you have in Alaska, that we have in South Dakota, that are all over, and be able to use the Internet to be able to manufacture parts and to share the parts.

In South Dakota, jewelry is very important for us. Black Hills gold is great. And we now have the ability for a person to sit in their own home, design a piece of jewelry, rotate it around in virtual images, decide it is exactly what they want, press a key. The machine will then cut the mold. The jewelry can then be cut and ultimately sold.

That changes the way we do business. Because it gets down to that individual who has the chance of being able to be in worldwide commerce. Without that kind of connection it would just not occur.

Senator STEVENS: Well, I agree with you. We are working on the telecommunications bill in this committee, and I hope we can soon get it. It is an integral part of this, to have the digital capability for the whole country, particularly rural America.

I will tell you, gentlemen, we have got a series of questions that we would like to ask. I am going to ask the staff to send them to you, and see if you can give us the information for the record. They need not be long answers. I think they are fairly specific questions.

[Note: The above questions were written questions from Senator Burns and Senator Pressler. They can be referenced in the Appendix with responses.]

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[The information referred to follows:]

Senator STEVENS. Let me tell you my problem here. I do not know whether you faced it, but we opened up the Internet in a couple of instances to communications and one Senator said he had 30,000 messages in 1 day. So I said, well, what do you do with those messages? He said he had a way to tag the ones that came from the State, and they were analyzing those to see what they would answer. And I said, what do you do with the rest of them? I said, in effect, you burn them, right? Well, you do not have enough time to answer them.

So then you get down to the question of how many of the ones that come from your own State really need answering. And that takes some time and manpower.

My question to you is, in terms of again, getting back to rural America, we have got many places in our State where there are no computers in the whole city. And we have to find some way to keep

up. The electronic mail that many of our people are using—you are using electronic mail—are not available there.

Congress is stopping the funding for newsletters. You are writing a newsletter. And you are writing it at Federal expense. That is why I was trying to ask you how much it cost to do this. We now have senators that want to put up, as I said, their Web page every day.

Well, that is a newsletter every day we are in session. And yet we cannot get the money to mail one newsletter once a year to the people who do not have computers. There is a fairness question. It is what I am coming to, in terms of rural America. What about the people who do not have computers? How are we going to deal with them in your system?

Have you got any way to reach out to find some ways in communities or somehow to have a central computer? Should we look to the post offices to see if we should put one of these in the post office so that people who do not have computers could come in and communicate with you? Where do we fit the nonuser into this?

Dr. RUNNING. Yes, sir, the post offices, the libraries, the economic development areas are key areas to start with, and the government centers. And we have been very active, as I know the Congress has.

Senator STEVENS. Well, I have got to tell you, with the downsizing of government, there are going to be a lot of places that do not have Federal offices. They certainly will not have many Federal employees in towns of under 10,000 very soon. We are downsizing government. And I think you have got some answers here to increasing communication and information to people in rural areas, but I do not think we can assume that everybody is going to have a computer or everyone is going to have access to the World Wide Web.

Dr. GOWEN. I am afraid you are right.

Senator STEVENS. What are you all doing to deal with that problem?

Mr. TOOLE. Senator, the industry is really responding, too, in the whole wireless revolution-satellite systems are being put into place, so that you can actually download things without hard wired computers. There are kiosks that could be put around. There are a lot of different ideas and experiments across the country that I am aware of that are actually ongoing.

Senator STEVENS. Have you gone into any Indian reservations or small Alaska Native villages and seen any place you could put a kiosk or a downlink?

Mr. TOOLE. Well, sir, I can only speak—that I know personally of a South Dakota Indian reservations that they have actually been trying to do some of that kind of linking of those schools and the Native Americans that I referred to earlier in my testimony, to help and extend that kind of thing to that group of people.

Senator STEVENS. Well, again, I was talking about the education section. We have only got a few areas where they have total computerization in the schools through the whole State. I think most of them are still experimental programs in school.

Mr. TOOLE. Right.

Senator STEVENS. Are you all giving us a program that is designed for the elite and the well-to-do? What about the rural America that is poor and does not have access to these computers?

Mr. TOOLE. I believe what you are seeing across the whole Federal Government is a wealth of different programs that have to be looked at cooperatively in how they interact. For example, I am just talking today on behalf of the Federal HPCC Program. However, three or four or five other programs probably were mentioned from education, to EPSCOR, from NSF and other things, which are very, very fundamental to the populace as a whole.

What we are trying to do is provide additional research and development in the Federal HPCC Program that is really going to make a difference as we explore how these things could be communicated and interacted with and given to the actual citizens.

In addition, the marketplace, to itself, is providing a lot of different capability, but it does require money. It requires money at the Federal, individual or State level. And that is very critical, I think, to be able to provide this universal access, which is a fundamental principle that we are trying to achieve through all of our programs.

Senator STEVENS. Well, I wish I could agree with you. I am not sure, I have got to tell you. We are spending more now on telecommunications and acquisition of this type of gear——I call it "gear"—of all the systems than we used to spend on newsletters. Yet the system says stop the newsletter, but spend more money on these things which will be communicating with only a portion of the population and a portion of the schools.

Many school districts cannot afford this system. Many universities cannot afford this system. You have got a very very visionary State that will give you $2 million to experiment, Mr. President. My university is being cut back right now because of lack of money.

Now, I am just worried about what you are giving us. You are giving us a system that the country is going to. But are we going to have some people left out of this system?

Dr. RUNNING: Well, Senator, I hope you realize that we can bring these same systems on a laptop computer that costs less than $2,000. I was checking out my Web site yesterday afternoon on a little laptop. So it does not take million-dollar investments now to get into this system. It does take $1,000 or $2,000 for a low-end PC. But we are not talking millions for it.

Senator STEVENS: I understand that. But I represent people that do not have the $1,000.

Dr. RUNNING: Well, yes. And I recognize that.

Dr. GOWEN: Senator, one of the things that I think we talk about today is more with less. And so what we are trying to do is make the system to match what we currently have resources for.

The reason South Dakota invested the money in this system is because we know that unless we find out how to live with less, there is not a future. The country is moving to cut the umbilical cord. As the president of the university, I know that I cannot depend upon the resources simply to keep coming from the same place. We have to change what we are doing.

We have to get out in front, and try to serve the industry in a way that the industry will pay for services that have value. With-

out services of value, the money will not be there either from government or industry.

The United States Congress cannot afford to continue to invest in the current level of services. We have to find new ways. Perhaps improvements in technology will bring the cost of these services down to a point where they are inexpensive enough that the person who must do business can afford to use such services.

Senator STEVENS: Well, certainly what you and Dr. Running showed me indicate that we do have institutions of higher learning that are trying to bridge that gap. I think it is a tremendous step. I do not know how long it is going to be before there will be an absolute requirement to be computer capable in this country. But it means that children are coming out of the school districts who do not have that capability now are going to be left behind. And somehow or other we have got to give it to them.

I remember, and I am boring you perhaps, but I had a young man come into my office from Alaska. He got into this and was very capable at it. For several mornings when I came to work I saw him coming out of the office. I could not figure it out. He just said, I cannot stop once I get started at night. He was staying there all night literally to get into the Library of Congress, and I remember he was in the New York Times library. He was even into some of the University of Alaska's library, just seeing what was there.

There is an insatiable interest in what you are doing in young people. There is no question about it. But it is still fairly limited access that we have got. That is why I am interested in this information highway concept. I think we have to have some way to deal with public terminals somewhere so people can go to have some ability to get into this information bank, who cannot afford even a laptop, Doctor.

Dr. RUNNING. Well—and I think some of the other people here can make this more clear—but certainly any house with a telephone line—that is really the minimum hardware required—a telephone line and the price of the computer is coming down every month. So I agree there is still a lower limit. It is not zero, unfortunately. But it is getting to be a lot smaller just every year.

Senator STEVENS. You are from Montana, right?

Dr. RUNNING. Right.

Senator STEVENS. Well, I went to Bozeman years ago.

What is the penetration for computers, by population, in Montana today? What percentage of the homes have a computer?

Dr. RUNNING. I am not sure. That is an interesting question. I suspect it is fairly high. I would estimate it would probably be—I know around the Missoula area, which is a university town, it is something like 60 or 70 percent.

Senator STEVENS. I would expect that. I do think that if we are going to build a system based upon everybody having a telephone line and a computer, we better look at the statistics. We have still got a lot of places that do not even have a television, which is free, and all you have to have is something to plug into electricity.

So it is a very important thing. We appreciate your help, and I am sorry more of my colleagues could not be here this morning. But we do appreciate your answers to these questions that are going to come to you, because I think it is a most important subject

for us as to how far we are going to go to continue and to put the high priority on Federal support of this kind of endeavor.

I think it should have a very high level of priority, and you are going to help us keep it up there with your contribution. Thank you very much.

[Whereupon, at 12:15 p.m., the hearing was adjourned.]

APPENDIX

QUESTIONS ASKED BY SENATOR PRESSLER AND ANSWERS THERETO BY DR. JOHN C. TOOLE

Thank you for the opportunity to respond to additional questions as part of the recent hearing on the High Performance Computing and Communications (HPCC) Program and World Wide Web Demonstration.

Enclosed are the answers to the questions from both Senator Burns and yourself for inclusion in the printed record of the May 4 hearing. I am also enclosing additional copies of the FY 1996 Supplement to the President's Budget, the FY 1996 HPCC Implementation Plan, and the CIC Strategic Implementation Plan which are referenced in the answers. Thank you for your interest in the HPCC Program.

QUESTION 1. Mr. Toole, how much is the FY 1996 budget request for the federal High Performance and Communications (HPCC) Program and what agency activities are supported by the request?

Answer. The FY 1996 budget request is for $1,142 M across twelve Federal departments and agencies. The Program is designed to ensure US leadership in information and communications technologies and consists of 5 components: High Performance Computing Systems (HPCS), National Research and Education Network (NREN), Advanced Software Technology and Algorithms (ASTA), Information Infrastructure Technology and Applications (IITA), and Basic Research and Huraan Resources (BRHR).

The individual agency activities are documented in the FY 1996 Supplement to the President's Budget, titled "High Performance Computing and Communications: Foundation for America's Information Future," which has been provided to the Committee. In addition, each organization's request is described in detail in the "FY 1996 HPCC Implementation Plan," dated May 16, 1995. These documents were prepared by all participating organizations and comprehensively answer your question. Copies of the Implementation Plan have been forwarded for your staff.

QUESTION 1a. Mr. Toole, critics assert that the federal HPCC Program is too large, lacks focus, and commits too few resources to the activities of the individual federal agencies that participate in the program.

Answer. Let me address each of these separately. First is the issue of program size. Out of a total $73 B in FY 1996 for Federal R&D, the Federal HPCC Program represents only 1.5%, and HPCC is an area generally regarded as one of the most critical to America's future. The Program is approximately half of the Federal R&D investment in information and communications, as described in the Committee on Information and Communication's Strategic Implementation Plan, "America in the Age of Information," dated March 1995. The Program is a balanced program that is the right size to meets its objectives on schedule, as is well documented in the FY 1996 supplement to the President's Budget. In addition, major studies including the February 1995 National Research Council (NRC) report, "Evolving the High Performance Computing and Communications Initiative to Support the Nation's Information Infrastructure," have affirmed the critical value of the Program, its contributions to the advancement of high performance computing and communications, and the need for increased emphasis on R&D of technologies for large-scale, integrated information infrastructure. This report recommends continued funding at the current level.

The second issue is the focus of the Federal Program. The HPCC Program goals, articulated in the FY 1996 supplement, are derived from both long term science and technology objectives and the missions of the participating agencies. The agencies carefully coordinate their efforts to encourage cooperative ventures where possible and avoid unnecessary duplication. The nature of information, computing, and communication demands an innovative, dynamic, and sustained long-term investment. Complex but successful strategies cannot always be reduced to simple terms, which is sometimes confused with lack of focus. Furthermore, a successful R&D program must exploit new opportunities, building upon its research base. An example is the Information Infrastructure Technology and Applications component, which was added in FY 1994 to address some of the longer term R&D needs of the National Information Infrastructure and stimulate advanced applications.

The third issue is the commitment of resources, which are determined by each agency according to its mission requirements and priorities, after reviews by OMB and the Federal HPCC Program. Long-term R&D included in the Federal HPCC Program is important to many other downstream mission programs, which are users of advanced technology. Taking a systems perspective, the strength of the Federal

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HPCC Program has been rooted in its ability to have major leverage and impact on other major programs even though they are NOT part of the Federal HPCC crosscut.

QUESTION 2. Mr. Toole, critics of the HPCC Program assert that, intentionally or not, it influences commercial developments. For example, a decision by the HPCC Program to concentrate on a particular computer technology might cause the marketplace to follow suit where it might otherwise have gone in a different direction. What is your answer to this criticism? If the HPCC Program does skew commercial development, is it necessarily against the public interest? If it is against the public interest, what steps should be taken in the program to ensure the HPCC Program does not drift toward "industrial policy," that is, picking winners and losers?

Answer. Projects are competitively selected, allowing fair and open competition to all. The HPCC Program participants do not, and have never, advocated a particular industrial policy. R&D programs should explore innovation, creative approaches, and sometimes competing solutions that ultimately reduce risk, quantify or eliminate barriers to progress, and enable long term missions to succeed. In 1994, approximately 55% of the Program funding went to academia, 20% to industry, and 25% to government labs/not for profits. This is NOT a profile of "industrial policy," even though critics have confused the focus of the Program.

While the Program is proud that our R&D efforts have been of great value to industry (e.g., communications protocols leading to the Internet, web browsers leading to a new industry, scalable parallel systems now embraced across industry), it is the marketplace that will ultimately determine viable commercial developments. The companies themselves must make individual choices to invest in new technologies after weighing the risks. It is in the public interest to fund long term strategic research that will help stimulate innovation. Keeping a long term focus on research and leading edge demonstrations insures there is no drift toward "picking winners and losers."

QUESTION 3. Mr. Toole, the HPCC Program now has in its budget nearly all of the federal funding for computing research of any kind. Because of this sort of arrangement, reduced funding for the HPCC Program could cripple all computing research. Is this a wise arrangement?

Answer. While the HPCC Program focuses on the high end of computing research and is positioned to address needs not being addressed by non-Federal programs, it is not all of the computing research budget. It is also true that reduced funding for the HPCC Program could cripple computing research, particularly in academia. Independent of its size, I suggest that there should be bipartisan recognition and support for the Program's accomplishments; its ability to coordinate effectively across participating agencies; and its visible focus on computing research that maintains national priority and assists R&D oversight. HPCC technologies developed in this Program are critical to major downstream programs not included as part of the HPCC Program, as well as to the success of other NSTC committees.

QUESTION 4. What are some of the cutting-edge advances the HPCC is expected to produce in the next few years? How soon might we actually see a "teraflop" computer...?

Answer. Several highlights we anticipate in the next couple of years include:

- High availability systems scalable to one teraflop per second performance
- Individual gigaops processors based on 0.2 micron line widths providing millions of electronic gates per chip
- Prototype networks with 40 gigabit per second throughout, using optical technology
- Global climate and weather models coupling atmosphere, oceans, sea, and ice models that are capable of providing both short term weather phenomena (micro bursts, tornadoes) and long term climate effects (El Nino and La Nina)
- Digital library technology that provides a wide variety of multi-media to citizens across the country, especially in rural areas
- Connection to the Internet of a very large number of K-12 schools, health-care centers, libraries, businesses, and homes

Cutting-edge HPCC advances in previous years and on-going scientific research are described in the annual supplements to the President's budget, generally called the HPCC Blue Books. Just as the Nation is able to exploit the benefits of sustained R&D investments over the last 10-15 years, HPCC's greatest impact will likely be felt many years from now and in ways that may not be predictable.

The scalable technologies to build a general purpose "teraflop" computer will exist in the next year, but this is a direction, NOT a destination. The mutual leveraging of technologies and ideas across layers of the Program have enabled the transition of scalable concepts to scalable prototypes to scalable systems, which are progressively more general and affordable. The Program has reached the point where a typ-

ical large scale computing complex in the $40-$50M range is now emerging. However, it would be too expensive and inappropriate for an R&D program to build a teraflop computer system at this time. Applications that can effectively exploit this capability have been demonstrated at smaller scale. It is now primarily a matter of mission need, system economics, and software development for the first teraflop systems to be put into operation. This will likely happen within the next two years.

QUESTION 5. Mr. Toole, would you comment on what you feel have been the strengths and weaknesses of a program that is coordinated across several federal agencies? It has been said that coordination can help enhance program diversity while preventing unintended duplication and redundancy. Is this means of program management one the government should pursue in the future in other areas?

Answer. The strengths of a coordinated program are exactly as the question indicates—it helps enhance program diversity, prevents unintended duplication, and allows technology to flow among agencies. In addition, it enables much faster decisions across multiple agencies and provides unique opportunities—a mission agency gets to use the technology earlier while the researcher receives vital feedback.

Another important aspect of the Program is the national priority given to HPCC. Research and development in HPCC technologies has been supported in a bipartisan way for many years. The unique management of this Program has been critical to achieving this priority status. With coordination at the national level and management by participating agencies, the HPCC Program has achieved a balance that the agencies want to maintain.

I can think of no obvious weaknesses of such coordination, except perhaps the amount of added expense in providing the coordination function, which in the case of the HPCC is a small fraction of a percentage of the entire Program. In fact, the coordination process adds value to the participating agencies. The Program may be thought of as a "federation" of collaborators that build on each other's strengths. This model should be considered for other areas on a case by case basis.

QUESTION 5a. Mr. Toole, what sort of mechanisms does the HPCC Program have for obtaining the views of industry and the scientific research community?

Answer. The HPCC Program is one of the most open government programs and solicits comments through both formal and informal mechanisms. It interacts with industry and academia at several levels. First, information that is widely available to the public generates intense feedback to program management. The National Coordination Office (NCO) regularly publishes and maintains its documents on the World Wide Web—the Blue Books, the Implementation Plan, the CIC Strategic Implementation Plan, congressional testimony, workshop information—a wide variety of information concerning the HPCC Program and its participants. Many agencies provide very detailed information about their research efforts on the Web.

Second, the NCO and participating agencies sponsor workshops and fora involving the academic and industrial communities on various aspects of HPCC, such as computer systems, mass storage systems, gigabit network testbeds, and Grand and National Challenges. In addition, HPCC agencies sponsor principal investigator meetings and open scientific symposia, which serve as avenues for feedback with the scientific research community. Throughout the year, the NCO and the agencies participate in many briefings, meetings, and discussions with various industrial and research organizations. HPCC is strongly supported by many organizations, such as described in a letter to Senator Dole from the Computer Systems Policy Project (CSPP), May 24, 1995, an affiliation of Chief Executive Officers of thirteen American computer systems companies.

Third, there is a formal means of feedback involving several agencies. Advisory councils in many organizations address the scientific and technical directions of various agency programs. In addition, I'd like to see the establishment of an advisory council to support the Committee on Information and Communications, which includes the HPCC Program.

QUESTION 6. Mr. Toole, the single, most vibrant and robust business segment of this nation's economy is that which builds computers, writes software, and manufactures and installs communications technologies. This combined market segment is now, and has been for several decades, a primary driver of the economy. When one thinks "business success," one tends to think "Silicon Valley" and "high tech." Given the sheer health of these industries and their responsiveness to the marketplace and the competitive forces driving them, does it make any sense, Mr. Toole, for the government to be spending about a billion dollars a year to help these industries?

Answer. "Silicon Valley" and "high tech" are certainly business successes in the United States. However, it should be noted that early government investment in information technology decades ago was also an enabler of Silicon Valley's success. The government role is to focus on the longer term fundamental issues that are be-

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yond the time horizon of business and address strategic issues and problems. As pointed out in the National Research Council report referenced earlier, it is the long term government investments in these areas that have substantially contributed to the successes you cite. Unfortunately, R&D spending in these areas has declined, as reported by the Wall Street Journal on May 22, 1995, which puts even greater reliance on long-term government funding. To stay ahead, someone must invest in the long term—industry cannot, but government can.

While it is true many segments of the information technology industry are enjoying unprecedented success, certain market segments are not as healthy as the ones you cite. The costs of development of new high end products, the slow pace of market development, and the effect of international competition on profit margins, have taken their toll on high end computing systems.

The HPCC Program supports long term R&D in information and communications that will mature in the 5-15 year time frame. Viable industries, whether in computing or any other technology, do not concentrate their resources on such long term goals. In order to stay competitive, they must focus on shorter range goals, achievable as products in one or two years or even less. The billion dollars invested by the HPCC Program fills this long term R&D need and supplies a stream of creative and talented researchers who will develop the future generations of technology.

QUESTION 7. Mr. Toole, I'm sure you've heard of "ITS" or "Intelligent Transportation Systems," which used to be called "IVHS" or "Intelligent Vehicle Highway Systems." ITS programs are funded by the Federal Government and mandated by the 1991 "ISTEA" law ("Intermodal Transportation Efficiency Act"). ISTEA money comes from the Federal Highway Trust Fund, which gets its money from the gas taxes we all pay. ISTEA money is available to states and local agencies.

I'm sure you are aware, as probably no other man in the Federal government, that the telecommunications industry in this country is spending enormous amounts of money to put thousands of miles of fiber optic cable in the ground; to buy high speed digital switches; and to create high capacity, interoperable wireless systems. But what you may not be aware of Mr. Toole, is that in parallel to the telecommunications industry, ITS-funded projects are building networks separate from the rest of the nation's and with no interoperability! These networks are being built with public funds—a clear competitive threat to private sector telecommunications enterprises, as supported by the current Administration.

Mr. Toole, would you care to comment?

Answer. The ITS is an important Department of Transportation (DOT) Program, and the issues you raise are important ones. However, there are no simple solutions, given the technical, regulatory, and economic climate. Although DOT is not an HPCC agency, it is looking for creative solutions to its problems and has undertaken a major effort to bring together state and local transportation agencies and telecommunications firms to resolve their mutual concerns. The first ITS Telecommunications Infrastructure Forum was held in April of this year, providing an opportunity for discussion of the problems that have led agencies to establish their own systems and to share ideas about exciting possibilities for cooperation. DOT intends to continue to foster this productive dialogue.

QUESTIONS ASKED BY SENATOR BURNS AND ANSWERS THERETO BY DR. JOHN C. TOOLE

QUESTION 1. Mr. Toole, *"High Performance"* is a shaky target; continually moving because of the steady gains in the performance of computers, and in their cost. The computer on my desk, for example, is incredibly inexpensive and yet is as powerful as most computers of 1979. Yesterday's supercomputer is tomorrow's desktop workstation. Mr. Toole, how does the HPCC Program deal with this situation?

Answer. High performance computing and communications programs do, in fact, produce technologies that migrate to the desktop. This is one of the greatest contributions our HPCC Program can make to our society, its economy, and its industries. Such migration is a planned consequence. The technologies we are developing in today's R&D program, such as high performance scalable computing systems, will be in tomorrow's desktop, when our R&D is looking at even more advanced technologies.

QUESTION 2. The original goals called for creating dramatically faster computers and networks, using as drivers to stretch the limits of computing the challenge of solving so-called "Grand Challenges"—scientific and engineering problems that can only be solved through the use of incredibly faster, more powerful computing power. But, over the course of the HPCC Program's last four years, the focus seems to have shifted instead towards looking at broader uses of computing and communications.

Mr. Toole, would you agree with this assessment? If you do agree, would you comment on whether or not this shift in emphasis is appropriate?

Answer. I agree that the Program has added a component that looks at the challenging broader uses of computing and communications. However, it continues to build a solid scientific and engineering foundation. Progress in these areas is documented in the FY 1996 Blue Book. "Grand Challenges," and later the information intensive "National Challenge" problems were established to ensure we have a set of important application prototypes and testbeds sufficient to measure progress in HPCC technologies. Both sets of problems require powerful computing and communications, and intentionally demand interdisciplinary approaches that also encouraged interagency cooperation for the long term benefit of the government and the citizenry.

In the future, we can expect that scientific results developed as part of the Grand Challenges, combined with National Challenges, will greatly enhance the quality of life for Americans. Weather forecasting and health care are two good examples. NOAA has developed a hurricane prediction system, using modern techniques requiring high performance computing, that can more accurately predict the path of a hurricane, provide earlier warning to affected communities, and in turn, save lives. This requires powerful computing as well as almost instantaneous dissemination of critical information. In the medical field, applications of telemedicine that use advanced communications networks and computationally intensive calculations can bring the physician instantly in contact with patients in remote locations.

It is extremely important to have a balanced approach to long term innovative research in computational and computer science, communications, and information technology. These results need to be made rapidly available to a broader community of individuals. The research needed to make this happen is part of the current Program.

QUESTION 3. NASA and DOE both operate their supercomputer centers to allow general access to users; this is paid for by non-HPCC funds. The research conducted in such cases is not, however, computing research; instead it is research that is "merely" using the computer as a tool. HPCC research conducted by both NASA and DoE is funded, then, by the use of HPCC funds. This does not seem to be the case, unfortunately, with NSF. Mr. Toole, why is NSF using HPCC funds to pay for non-HPCC research? Isn't this sort of commingled funding support unhealthy in the long run to the research community?

Answer. The apparent disparity in accounting is based on both differences in mission needs and HPCC Precedent. The mission agencies, including NASA and DOE, must support "production" computing to provide well-known production components for their missions. The nature of the work in leading edge computational science applications naturally includes both uses of computing. For example, the National Energy Research Supercomputer Center at Lawrence Livermore National Laboratory and NASA's Numerical Aerodynamics Simulation System at Ames Research Center, also must conduct strategic high performance computing research to enable the development of advanced tools and techniques for use by the energy research and the aerodynamics communities.

In the beginning of the HPCC Program, only centers with broad, general access were included, although other centers sometimes became early users of the technology. This is consistent with the way that NSF operates the National Center for Atmospheric Research (NCAR), which is not HPCC funded. The mission of the other NSF centers is to advance the broad field of computational science and to develop the infrastructure required to make advanced computing systems more easily used by the science and engineering community. Thus, there is more focus on computing research at NSF centers, but not exclusive as noted above. This role, for example, has allowed them to lead the community in advancing the emerging paradigm shift to parallel computation.

As a result, a consistent principle has been applied to counting HPCC funds, subject to the appropriate mission interpretations. The NCO and the agencies are carefully reviewing this area to insure consistent application in the FY1997 budget process.

In the long run, both types of funding should be strongly supported—computing as a tool through mission programs and the advancement of computing research through HPCC and other funding. At these NSF centers, scientists from other fields need the opportunity to use the best computational capabilities possible while forging ahead new computing research. The coupling of computing research, computational science, and leading edge applications has often been key to the progress reported to date.

QUESTION 4. Would it make more sense, Mr. Toole,for the government to promulgate standards to bring the NII into existence rather than for it to fund re-

search? Or, to go even further, would it make even more sense for the government to only help to have such standards promulgated? Or should government be proactive and propose NII infrastructure goals?

Answer. Promulgating standards and research are not mutually exclusive, and both are needed to realize the full benefits of a robust information infrastructure. Practice has shown that the most successful standards are those that are developed after research and proof of feasibility. Standards will bring a current generation of information infrastructure into existence, and research will enable an innovative future generation. In addition, research supports the ability to set intelligent and implementable standards, just as many of today's standards have grown out of past R&D efforts.

In addition to the research role, the government is also one of the primary users of information and communications technology in performing it missions. It should be a significant stakeholder as an advocate of standards that will cost effectively support those missions, and promote interfaces into commercial systems. However, the primary standards setting process should rest with industry, which must ultimately develop products. A robust R&D program among academia, industry, and government is important to the Nation to reduce risk by addressing the fundamental barriers and to continue innovation.

QUESTION 5. Mr. Toole, would you agree with the proposition that we should just let the NII come into existence on its own, as seems to have happened with the Internet and our current telecommunications switched networks? Shouldn't it be policy of US government to let the marketplace determine and drive the evolution of the NII?

Answer. It may appear to just have happened, but the Internet was spawned by federally supported research over several decades. Technology for the Internet was invented by government research and the initial infrastructure set into place to meet government research needs. According to Dr. Vint Cerf, Senior VP for MCI Telecommunications Corporation, "today's multi-billion dollar industry in Internet hardware and software is a direct descendant of strategically motivated fundamental research begun in the 1960's with federal sponsorship." The Internet grew from research in packet switching that led to the ARPANET, connecting first only very few universities and research laboratories. Research investments spawned Internet protocols, applications such as electronic mail, and early network deployment of major networks by NSF and other agencies that have led to what we call the Internet today. Of course, the Internet today is self-supporting, with the government a major user.

The marketplace will indeed determine and drive the evolution of the NII, but the marketplace can never explore a "space" that isn't enabled by research. However the NII evolves, whatever industrial and societal forces combine to produce it, the HPCC Program will contribute to the future of information technology in tomorrow's NII. Research support in these vital areas is important to meet the long term needs of agencies and the country in a timely manner.

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